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95th Congress
2d Session

COMMITTEE PRINT

LIQUEFIED NATURAL GAS: SAFETY, SITING, AND POLICY CONCERNS

PREPARED AT THE REQUEST OF

HON. HOWARD W. CANNON, *Chairman*

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE

JUNE 1978

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LETTER OF TRANSMITTAL

U.S. Senate,
Committee on Commerce, Science, and Transportation,
Washington, D.C., May 31, 1978.

Dear Colleague: As chairman of the Senate Committee on Commerce, Science, and Transportation, I am pleased to provide you with this timely and valuable committee print entitled "Liquefied Natural Gas: Safety, Siting, and Policy Concerns."

In light of the current interest in various issues raised by the importation, storage, and distribution of liquefied natural gas (LNG), I believe this document will provide useful background information for those concerned with the future role of this industry in meeting our national energy needs.

While this report has been neither approved, disapproved, or considered by the Committee on Commerce, Science, and Transportation, it is hoped that it will provide useful background information.

Sincerely,

Howard W. Cannon, *Chairman.*

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LETTER OF SUBMITTAL

THE LIBRARY OF CONGRESS,
CONGRESSIONAL RESEARCH SERVICE,
Washington, D.C., April 11, 1978.

Hon. HOWARD CANNON,
Chairman, Committee on Commerce, Science, and Transportation, U.S. Senate, Washington, D.C.

DEAR CHAIRMAN CANNON: Pursuant to your request, we are pleased to submit the proceedings of the CRS seminar entitled "Liquefied Natural Gas: Safety, Siting, and Policy Concerns." The seminar, which was held on February 1, 1978, was designed to provide a background and orientation on the public policy issues associated with the increased importation of liquefied natural gas (LNG).

The seminar was an interdivisional effort drawing upon the expertise available in our Science Policy Research, Environment and Natural Resources Policy, and the Senior Specialist Divisions. The Congressional Research Service would like to acknowledge that the Office of Technology Assessment, Arthur D. Little, Inc., and many industry and public interest group representatives participated in this seminar.

John Jimison, analyst in environmental policy, of our Environmental and Natural Resources Policy Division, addressed the relationship between LNG and the natural gas supply situation. Dr. Warren Donnelly, senior specialist in energy, environment, and natural resources, reviewed past congressional interest in LNG. Paul Rothberg, analyst in science and technology, of the Science Policy Research Division, discussed the current issues and legislation concerning LNG import systems. Mr. Rothberg also served as moderator for the seminar and was responsible for composition of the highlights of the seminar and collocation of the final text. Jeannette Porter and Mary Veigle of our Science Policy Research Division, and James Price and Robert Nickel, of the Director's Office, contributed to the preparation and recording of these proceedings.

I trust that this study will be useful to the Senate Committee on Commerce, Science, and Transportation, as well as to other communities and Members of Congress concerned with the importation of LNG into the United States.

On behalf of the Congressional Research Service, may I express my appreciation for the opportunity to undertake this timely and worthwhile assignment.

Sincerely,

GILBERT GUDE,
Director.

PREFACE

On February 1, 1978, the Congressional Research Service (CRS) conducted a seminar for committee and Member staffs on the public policy issues associated with the importation of liquefied natural gas (LNG). The seminar was designed to provide a basic background and orientation on LNG.

Papers were presented on the operation of an LNG import system and on the relationship between LNG and the national gas supply situation. CRS reviewed past and present congressional interest on LNG. Legislation introduced in the first session of the 95th Congress was analyzed in terms of the major issues associated with increased importation of LNG. The Office of Technology Assessment (OTA) presented an overview of its recently completed work entitled "Transportation of Liquefied Natural Gas." Because safety is a major concern, special attention was directed at LNG properties, characteristics, and hazards; containment systems; and the measurement of safety of LNG systems.

CRS sought to obtain a variety of perspectives on the issues discussed in the seminar. To achieve this objective, representatives from several public interest groups, from industry, and from State and Federal agencies were invited to participate.

The proceedings of the seminar have been edited to provide a background and reference document for the Senate Committee on Commerce, Science, and Transportation.

CONTENTS

SELECTED HIGHLIGHTS OF THE SEMINAR

Importation of liquefied national gas (LNG) poses an array of policy issues, including: How much LNG should be imported? Where should LNG facilities be sited? Are Federal regulations adequate to insure the safety of LNG import systems? Should LNG be priced incrementally or should it be rolled in? Should Federal authority preempt State authority over the siting of LNG facilities? These and other issues are identified in these proceedings.

The legislative framework that exists for the control of LNG transportation hazards is largely the byproduct of legislation enacted for other reasons. To date, congressional interest has primarily focused upon the jurisdictional aspects of regulating the hazards of LNG marine transport. Though nine Federal statutes provide authority for the control of LNG hazards from ships and shore terminals, none of these statutes provides coordination of the exercise of these scattered Federal authorities.

Executive agencies and the President have made most of the major decisions pertaining to the LNG import industry. Final regulatory approval has been granted for several LNG import facilities; new Federal decisions on several other terminals are anticipated in the near future. These decisions will affect millions of gas consumers; however, Congress' role has been very limited, especially in the areas of safety, siting, and LNG pricing.

There are opportunities for several congressional actions concerning LNG. Congress could examine the need to: (1) Improve the Federal regulatory system, (2) strengthen and expedite Federal research and development on LNG safety, (3) design a Federal siting policy for LNG terminals, (4) create an LNG damages or compensation fund, and (5) maintain an active role in setting LNG pricing and import policy.

If the Congress decides to pursue these concerns, it will be important to consider the timing of its action in relationship to the expected growth of the LNG industry and pending Federal regulatory decisions. There is also the option of continuing the *status quo* in the way the Congress has previously dealt with LNG concerns; that is, primarily overseeing the industry and the Federal regulatory process.

The Federal regulatory system governing LNG facilities has been characterized as complex, as contributing to escalated costs, and as fragmented and inefficient. Many have questioned whether current regulations would adequately protect the public from the dangers posed by LNG. OTA indicated that the Coast Guard could conduct more rigorous inspections of LNG tankers, and that inspector training and inspection technology now in use could be improved. In addition, OTA found that current Coast Guard inspection does not in-

clude an examination of the propulsion systems on the ship, or of the navigation equipment, nor does it include a determination of crew competence. CRS suggested that the characteristics of the Federal regulatory system do not appear to be compatible with the optimal requirements desirable for a system that must regulate a material as potentially dangerous as is LNG.

Donald Allan, an LNG safety expert from Arthur D. Little, Inc., stated that the hazards of LNG have been identified; sufficient research has been conducted so that the hazards are reasonably understood; detailed and comprehensive analyses of failures have been conducted; and measures of risk have been derived. He noted that if LNG accidentally escapes from its container, it represents a hazard to both people and property. Being very cold (−260° F), it will freeze skin tissue on contact. Although it is not toxic, it can cause asphyxiation when it evaporates. LNG may also explode. Allan stated that if LNG vapor is mixed with air and ignited within some type of confinement, such as a building, the resulting rapid release of energy will cause the pressure of the LNG to rise to the point where the confining medium bursts or "explodes."

Allan asserted that the primary hazard resulting from the escape of LNG is fire. If accidentally spilled on the ground, LNG evaporates very rapidly; and if the resulting vapor is ignited right away, a fire will develop over the evaporating pool of liquid—and it will continue to burn until all of the liquid has evaporated. If the spill is large, the fire may be of substantial dimensions, and the resulting thermal radiation can cause injury and damage at some distance away from the fire.

Furthermore, Allan noted that if the vapor is not ignited, it will form a cloud that will move downwind. This cloud will remain just above ground level because the vapor is more dense than the surrounding air. However, the natural turbulence of the air will dilute the vapor cloud as it travels downwind—eventually becoming so diluted that it is no longer flammable. If the cloud is ignited at some point downwind before it becomes fully diluted, it will burn and cause thermal injury and damage to anything it envelops.

The seminar dealt with the potential importance of LNG to the domestic gas supply. Projections of gas use indicate that supplemental sources of natural gas will be necessary if the major traditional market sectors continue to demand natural gas in increasing quantities, and if substantial additional domestic supplies do not develop in response to higher natural gas prices at the wellhead. The major factor determining the timing of development and marketing of any of the supplemental sources of natural gas is whether or not such supplies would be incrementally priced to the user or averaged in with currently flowing gas. Ten criteria, including price, safety, security and lead-time, were used to evaluate the advantages of the various supplemental gas supplies relative to each other; and a rough assessment was made of how LNG measures up according to each of these criteria.

The seminar illustrated that different interest groups hold a wide range of views on the importation of LNG. For example, Max Levy, of Columbia LNG Corp., suggested that the Cove Point LNG import terminal "will prove to be a milestone in the mating of industry, the

environment, and safety, in addition to contributing significantly to our national well-being and growth." In contrast, a spokesman for BLAST (Bring Legal Action to Stop Tanks) urged that importation of LNG from Algeria be rejected for safety considerations, lack of national siting criteria, questions of sound economics and national security, and in the interest of achieving American energy independence.

The importation of LNG poses many issues that would be appropriate for increased congressional attention. This seminar was designed to aid the efforts of the Congress in this area.

CRS SEMINAR ON LIQUEFIED NATURAL GAS: SAFETY, SITING, AND POLICY CONCERNS

Introduction

FEBRUARY 1, 1978

Paul Rothberg [moderator]. Good morning and welcome to this congressional seminar on "Liquefied Natural Gas: Safety, Siting, and Policy Concerns." The purpose of this meeting is to enhance the knowledge of committee and Member staffs on the policy concerns associated with the emerging LNG import industry.

The seminar is divided into three parts. During the first part, we'll have a general orientation for those of you who are just beginning to learn, and become acquainted with, the issues associated with LNG. The second part of the seminar will be devoted to discussions primarily concentrating on LNG safety, siting, and regulatory concerns. During the third part, we will have an opportunity for representatives from citizens' groups, environmental concerns, congressional staff, and industry to discuss the issues raised during this seminar.

Our first speaker is Max Levy, of Columbia LNG Corp. He will present a slide show to illustrate in vivid terms how an LNG facility works. Next, John Jimison, of the Congressional Research Service, will discuss how LNG fits into the national energy situation. Then, Dr. Warren Donnelly, also of the Congressional Research Service, and I, will review past and current congressional interest on LNG. The second session will be devoted to discussions on LNG siting and safety by Peter Johnson, of the Office of Technology Assessment, and by Donald Allan, of Arthur D. Little, Inc.

We had originally planned to have Dr. David Rosenbaum present a summary of the GAO report; however, GAO is not able to present its report, since it is still in draft form.

Max Levy is our first speaker.

Part I. Background

A. How an LNG importing system works

Max Levy. On behalf of the liquefied natural gas industry, I want to thank you for the opportunity to speak at this seminar on LNG. My objective today is to describe the first major LNG import project to serve our Nation.

This project will result in increasing our natural gas supply by 650 million cubic feet per day, which equates to over 1 percent of our annual consumption.

The natural gas dedicated to this LNG trade is from one of the world's largest gas deposits—the Hassi R'Mel field—located in the

Sahara Desert in Algeria. It alone has reserves that total more than one-fourth of the proven reserves in the United States, including Alaska.

FIGURE 1. Hassi R'Mel gas deposits.

A 40-inch pipeline will transport the gas 315 miles from Hassi R'Mel to Arzew, a port located on the Mediterranean Sea.

At Arzew, a plant is presently being completed which will liquefy the natural gas. At the plant, the gas is cooled in stages until it reaches −260° Fahrenheit, at which point it is colorless liquid. A 600-to-1 reduction in volume from gas to liquid is achieved, thereby making it economical to transport it great distances aboard specially constructed ships.

The facilities in Algeria are owned and operated by Sonatrach, the Algerian national oil and gas company. The cost of these facilities exceeds $1 billion. A significant portion of the equipment and services used at these facilities were U.S. supplied.

The nine ships that will transport the LNG to the United States are owned and operated by subsidiaries of the El Paso Co. Three of the ships were built in France, three at the Newport News Shipbuilding Co., and three at the Avondale Shipyard near New Orleans. The total cost of the ships is $1.2 billion.

Each of the ships has a cargo capacity of 125,000 cubic meters of LNG which equates to 2½ billion cubic feet of gas. To put this quantity in a more understandable context, each shipload can supply the annual gas needs of over 17,000 customers in the Washington-Baltimore area.

FIGURE 2. Algerian liquefaction plant.

FIGURE 3. El Paso Arzew.

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This is a photograph of the El Paso *Paul Kayser*, one of the ships constructed in France.

FIGURE 4. El Paso Paul Kayser.

Compare this with the El Paso *Arzew*, which was constructed at Newport News (previous slide). Where the *Paul Kayser* had a relatively flat deck the *Arzew* has raised tank covers. The different configuration results from the use of different LNG containment systems. In other words, a different design for the tank shape, insulation, and support structure. These containment systems, of which there are five in general use, are of designs proven in years of service.

The LNG will be delivered to terminals located at Cove Point, Md., and Savannah, Ga. The Savannah terminal is owned by a subsidiary of Southern Natural Gas, which serves the States of Alabama, Mississippi, Georgia, and South Carolina. The Cove Point terminal is owned jointly by Consolidated Natural Gas and my company, the Columbia Gas System. Together, we serve the seven-State area of Ohio, Pennsylvania, Virginia, West Virginia, New York, Maryland, and Kentucky, and the District of Columbia. The two terminals are quite similar in design. However, I will focus on the Cove Point facility since I am most familiar with the construction and design of this terminal.

Construction of the Cove Point terminal was initiated in 1973 and today, over 4 years later, the facility is essentially complete. The total cost, including an 87-mile gas pipeline to tie the terminal to existing transmission facilities, is $369 million.

FIGURE 5. Location of Cove Point, Md., LNG Import Terminal.

Shown here is the 1,000-acre site that Columbia purchased for the terminal.

FIGURE 6. Detailed location of Cove Point, Md., LNG Import Terminal.

About 300 acres were rezoned for light industrial use. The remaining 700 will be retained in its natural state, and the State of Maryland will be given a scenic easement and certain rights with respect to environmental research on the property. The plant was laid out so that no operation would take place within one-third of a mile of the property line and so that the process areas would be surrounded at a safe distance on all sides by the thick existing woods. This will result in a plant which is not a danger to the public and which will offend neither the eye nor the ear. The fact that the tankers will be berthed and unloaded over a mile offshore will also mute the disturbances due to lights and noise and further enhance public safety. We did not choose to move this far into the bay for this purpose, however, but rather to avoid dredging a wide channel through the shallow areas, shown in light blue. The dredging of such a channel—and it would not be just a matter of a single initial dredging but of maintenance dredging at regular intervals—would have had continuing deleterious effects on the ecology of the bay.

After we received initial FPC approval, the Sierra Club appealed the Commission's order on the grounds that a proposed low profile trestle which would carry the unloading lines ashore from the offshore berths would cause visual pollution of the Chesapeake Bay shoreline and thus did not comply with the National Environmental Protection Act. Finally, fearing that the favorable terms of the gas supply contracts would be lost due to option lapses, Columbia and Consolidated agreed to construct an underwater tunnel linking the shore to the ship berths. With this and other major and costly concessions. the environmental groups agreed not to oppose the project.

This is an artist's conception of the plant.

FIGURE 7. Artist conception of Cove Point, Md., LNG Import Terminal.

The tanks are easily distinguished, each contained within its own dike, and the process area is separated from them. Tankage at the terminal totals 1,500,000 barrels. This figure, originally selected by the "two times tanker size" rule of thumb, has been confirmed as adequate by extensive computer simulation studies. Because additional storage will be required when other LNG trades are established at Cove Point, an area has been set aside for two more tanks. The four 375,000-barrel double-wall metal tanks are of a conventional, well-proven design. They have aluminum inner tanks and are insulated with foam glass on the bottom and perlite on the walls and roof. Four tanks were selected not only for operational reasons but to preclude overextending designs then in use.

Studies of vapor dispersion and thermal radiation effects were made before the tank locations, dike configuration, and office and control room areas were finalized. The locations and areas selected are predicated on confining fire exposure to Columbia's property in the extremely unlikely event of a full-dike spill. Flammable vapor concentrations, even under Brookhaven type D conditions, will not reach beyond the boundaries of the property at grade.

Our terminal consists of an offshore berthing facility, a tankage area, and what we have referred to as a process area. It is true that a baseload LNG terminal is in principle not very complex. However, its components are both large and extremely expensive. In addition, the handling of a cryogenic fluid adds complexities to piping equipment, instrumentation, and control systems.

Shown here are the basic parts and functions of the terminal. Liquid being unloaded is shown in red. By the combined use of pumps aboard the tanker and on the offshore platform, the liquid is moved at about

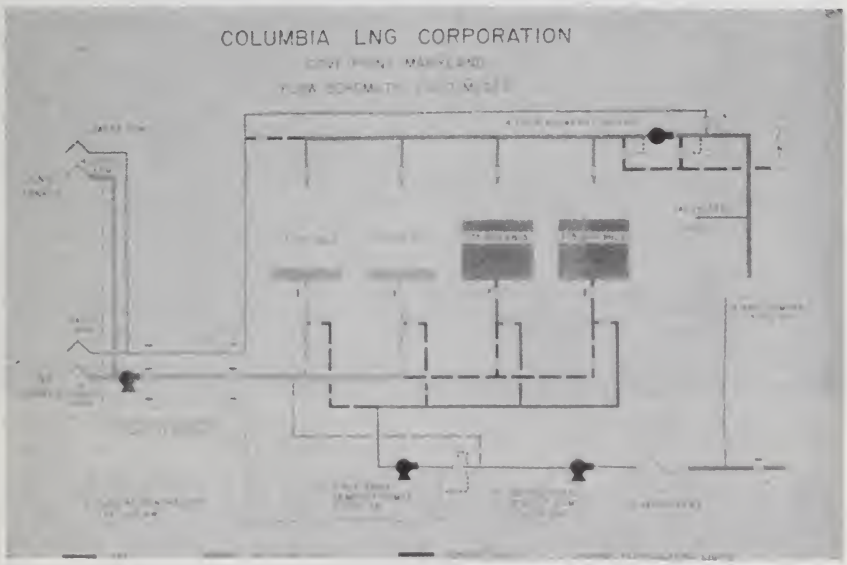


FIGURE 8. Flow Schematic.

50,000 gallons per minute from the tanker through over 2 miles of 32-inch diameter stainless steel pipe into the tanks. At the design throughput of the terminal of 1 billion cubic feet per day, a tanker will arrive every 2½ days on the average and be unloaded in about 12 hours. Liquid and vapor recirculation systems are included so that all lines, pumps, and valves at the terminal will remain cold at all times, thus not subjecting them to repeated thermal stressing.

Sendout liquid to the pipeline is shown in blue. When the plant is sending out a billion cubic feet a day of vaporized gas, it will empty two tanks in 2½ days, pumping out a rate of about 9,000 gallons per minute. Two sets of pumps in series will raise the liquid to a pressure of about 1,300 pounds per square inch; and at this pressure, it will enter the vaporizers, which are of the submerged exhaust combustion type, consisting essentially of tubes surrounded by agitated warm water. This slide shows the principle involved. In the tubes, the liquid will vaporize and directly enter the pipeline without further mechanical effort. The water surrounding the tubes is warmed by using specially designed natural gas burners. The products of combustion are forced through the water bath by blowers. This results in extremely efficient heat transfer, with exhaust gases from the process leaving at a temperature of only 110° Fahrenheit. The thermal efficiency of these units is 94 percent.

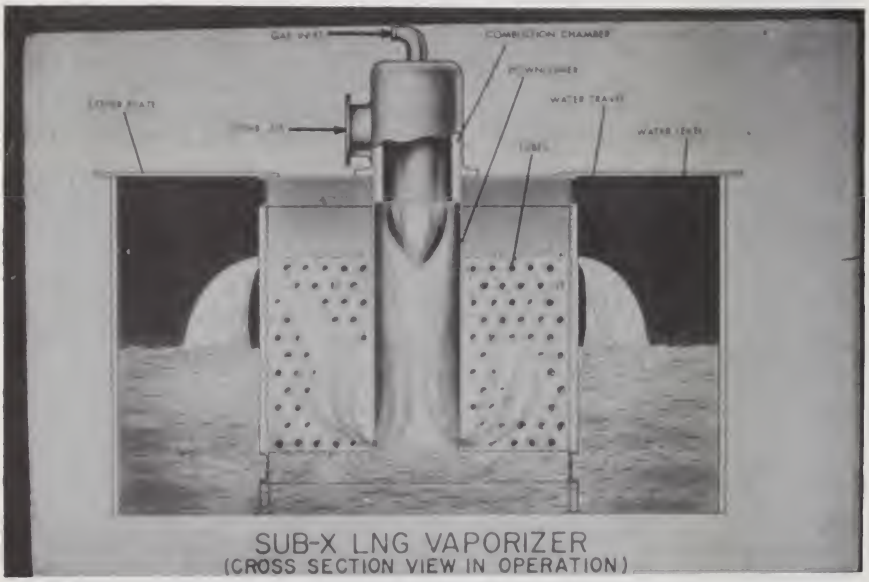


FIGURE 9. Cross-section view of LNG vaporizer.

Three 8,500-kilowatt gas turbine generator sets will provide electricity to drive the pumps and other equipment at the plant, and we will utilize the exhaust of these turbines to heat additional water for use in vaporizing the LNG. The vaporizers are indicated here with-

out showing the warm water piping to and from the turbines. No high temperature gases or liquids will ever contact tubes or pipes containing LNG. In total, approximately 2 percent of the terminal's throughput will be used for fuel, mainly for power generation and vaporization. The third system shown on this slide is the gas system, shown in green. Our boiloff will be compressed by centrifugal "cold blowers" and either used as fuel, sent through conventional gas compressors to the pipeline, or returned to the ship during unloading to displace the liquid being pumped out. The terminal is designed to be operated completely without venting. The greater portion of the equipment at the plant is housed or at least covered with shelters so that maintenance can be performed in the dry and with the aid of overhead cranes and adequate lighting. The buildings allow us to more readily detect gas accumulations or fires, and each contains an automatic water deluge system.

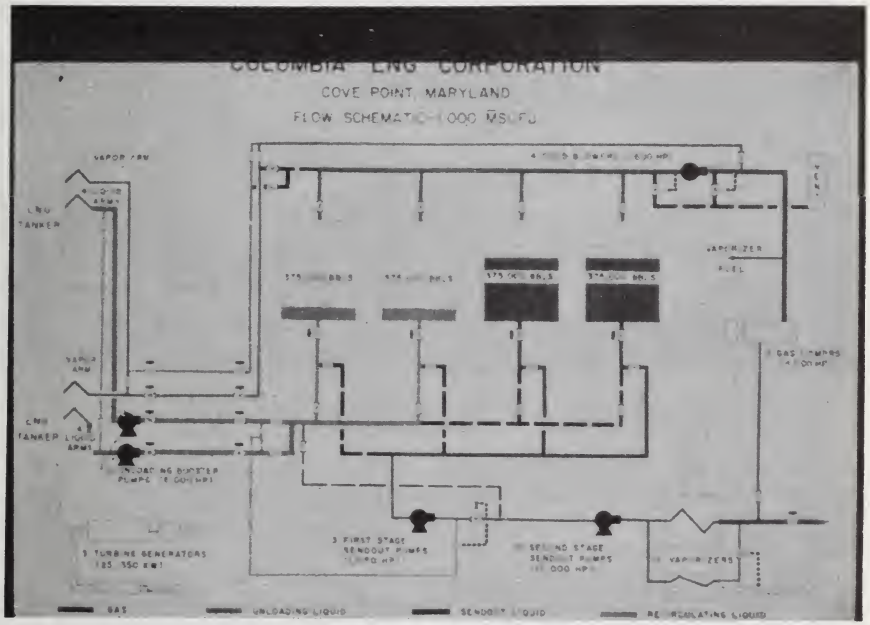


FIGURE 10. Flow schematic.

The offshore platform is an almost self-supporting facility with its own emergency generator, fire water pumps, dry chemical systems, waiting rooms, offices, and so forth. The tunnel has a narrow center compartment, separated from the compartments containing the LNG piping, which will provide access from the shore to the platform, but it will only be used by terminal personnel. Battery-driven cars will make the 1¼-mile trip in about 8 minutes. All other access for ships' crews, supplies, Government inspectors, and so forth will be by boat from a support facility El Paso is constructing at nearby Solomons, Md.

In conclusion, I have a few slides of the terminal construction. The first is an aerial view of the plant taken a few months back. As you can see, this approximates very closely the artist's conception shown before.

FIGURE 11. Aerial view of Cove Point, Md., LNG Import Terminal.

The second is a view of the tank dike construction. This was the first major use of the French "reinforced earth" concept in the United States. The panels are precast and held up by aluminum strips laid in the compacted soil.

Next is a view of the offshore facility, with berthing space for two 1,000-foot tankers. Operators in the prominent towers will have complete control of the five articulated 16-inch arms which attach to the ship, all the valving and pumps involved in the unloading, and the dry chemical fire water and emergency shutdown systems.

Total cost of the project, including the Algerian facilities, the nine ships, and the receiving and regasification terminals, will be close to $3 billion and is thus one of the largest industrial propects ever undertaken, second only to the Alaskan oil pipeline.

Even though the expenditures are enormous by normal standards, the cost of the gas to the consumer compares relatively favorably with other forms of gas sold in the U.S. market. The gas from Algeria will enter the pipelines of the Columbia Gas System at $1.66 per 1,000 cubic feet.

We have found, not completely to our surprise, that a design which is functional generally will have the added attributes of operational

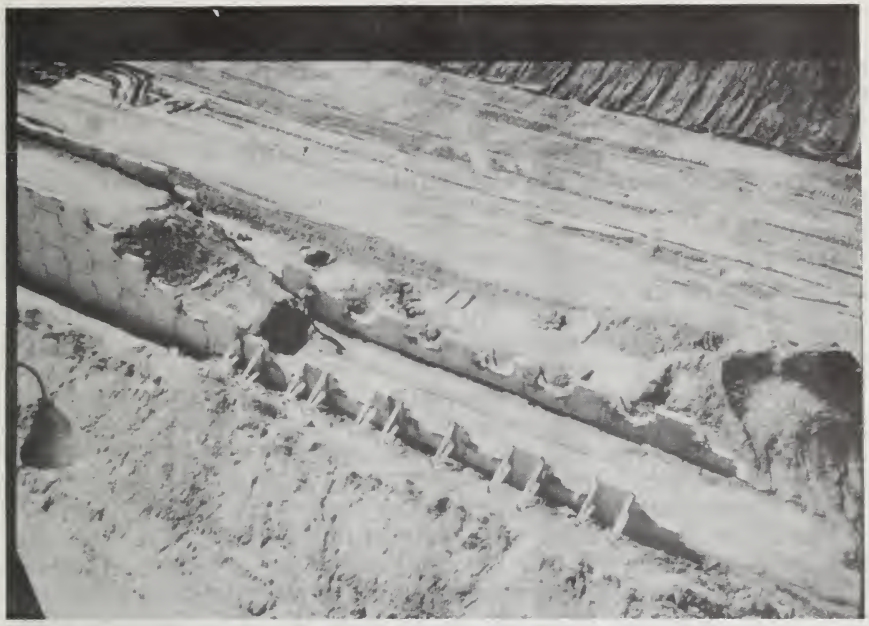


FIGURE 12. Tank dike construction.

FIGURE 13. Offshore berthing facility.

ease and economy and, comparatively speaking, of grace. We believe that the Cove Point terminal will prove to be a milestone in the mating of industry, the environment, and safety, in addition to contributing significantly to our national well-being and growth.

Thank you.

MODERATOR. Does anyone have any questions for Mr. Levy?

PETER HUNT [staff of the House Interstate and Foreign Commerce Committee.] Two questions—what is the Brookhaven Type D configuration?

MAX LEVY. It is a weather condition that includes a certain wind and a temperature inversion. It's theoretically one of the worst conditions under which a cloud will travel.

HUNT. Do you have any information as to the spill that recently happened at Arzew?

LEVY. I have very sketchy information on it. Perhaps Mr. Hunsacker can describe that better than I can.

BARRY HUNSACKER. I'm Barry Hunsacker of El Paso LNG. I can give you some details on that spill. They're a bit sketchy. The Coast Guard did send an investigator over, Dr. Jerry Havens of the University of Arkansas, who made a report on the matter to the Coast Guard. But, as I understand it, late at night, one of the Algerian operators went to a rather large cryogenic valve, in the range of 12 to 16 inches, on the discharge line from the pumps from one of the below-ground storage tanks—as you know they have, two below-ground storage tanks at Arzew—and the normal process for opening that valve is to first open a small bypass valve which is a couple of inches in diameter to cool the downstream side of the face of the large valve, so that the valve will not shatter or break.

Apparently that was not done, the small bypass was not opened, the large valve was opened, and the valve failed, causing the release of a considerable quantity of LNG, and I can't recall the exact quantity, but enough that the operator was killed from contact with the liquid. The facilities were shortly shut down, and nothing else of any event occurred.

That's about as much as I have on it. The valve was sent to Gas de France, and they've been examining the metallurgical aspects of the valve, and I do not have the results of that work yet.

QUESTION FROM AUDIENCE. When did that occur?

HUNSACKER. About a year ago.

LEVY. I don't think it was quite that long; I'd say about 6 months—5 or 6 months ago.

HUNSACKER. Somewhere in the summer, if I'm not mistaken—Mr. Norman says late in May of 1977.

HOWARD MARKS [from Senator Percy's office]. The OTA report, the Office of Technology Assessment, stated that there was, I believe, 4,000 ships moved each year through the Chesapeake Bay off the Point Cove facility, and that might pose a certain hazard, the collision hazard, regarding the vessels containing LNG, up against such a large traffic through that channel. I was wondering, in light of the fact that they raise that as an issue, a potential danger, what precautions have been taken by the operators of the vessels to counter those dangers?

LEVY. Well, the Coast Guard—it turns out that the path that the ship follows in the Chesapeake Bay is under the command of two different captains of the port—the captain of the port of Hampton Roads, and the captain of the port of Baltimore, and thus regulations have been issued, instead of normally by the captain of the port by the fifth district, which I believe is located in Portsmouth. And the actual regulations have not been issued publicly, and they will require—and I really can't say what they will require—I'm not trying—I just can't remember. Barry, can you speak to that?

HUNSACKER. I don't have that guide with me, but of course, they will enact a procedure much as they have at other U.S. harbors, for the arrival of an LNG tanker, which of course begins with the boarding of the tanker by Coast Guard personnel, and the inspection of the ship and all the cryogenic features, and the other features of the ship to make certain that it's worthy of transit up the bay, and I think initially they're restricting the operation to daylight hours only. They will send out the notice to other mariners that the LNG tanker is on its way, and in some of the passages they may restrict traffic to one way. I just can't be sure, but I would refer you to the Coast Guard who would be most happy to give you that information. I don't recall what you stated to be the source of the concern about shipping; was it the OTA report? Well, I think, perhaps, they're overly concerned about the traffic situation there. LNG, as you know, has been in transit in Tokyo Bay for 10 years—the Thames River for 14 years; Le Havre, France, for 14 years; Marseilles, France, for about 6 years; and several other harbors, all of which are much busier than Chesapeake Bay, without incident.

MODERATOR. Because of time limitations, we're going to move on now. Our next speaker is John Jimison of the Congressional Research Service. He is going to discuss how LNG fits into the national gas situation, will introduce to you some terms pertaining to the pricing policy of LNG, and will compare LNG to other alternative gas supplies.

B. How LNG fits into the natural gas situation

JOHN JIMISON. In my presentation, I will discuss the role of LNG in the natural gas situation. I will also briefly address the following concerns: Should incremental or rolled-in pricing be allowed for LNG? How secure are LNG supplies? How dependent should the United States become on imported gas supplies, including LNG? How does LNG compare to alternative gas sources?

I've made up a chart, the purpose of which is to put the prospective LNG imports in the context of both the historical natural gas supply-and-demand situation, and the probable future supply-and-demand situation. Because it would have been too confusing if it were all drawn out in advance, I will add lines to it as we discuss them.

The first task is to show what the gas supply situation has been. This first line that I'm tracing, from 1955 up to the present year, represents the available supply of natural gas to the United States on an annual basis, in trillions of cubic feet. This includes all marketed production, plus imports, minus exports—essentially, that gas that has been available to U.S. consumers, both interstate and intrastate. As you can see, starting in 1955, at about 10 trillion cubic feet, gas production and

availability accelerated, until it peaked in about 1973, at which point, because of reserve shortages available to interstate pipelines and other factors, the gas supplies available plummeted.

They now appear to be leveling off a little bit and not falling quite as fast as they were a few years ago.

Who has been using the gas that's been available? Residential consumers have always consumed a fairly important part of it, and as you can see, the consumption of natural gas by the residential sector experienced fairly slow but steady growth right up to the peak of supplies in 1973. Then there was a minor dip, due to conservation, and no new hookups, but the growth has apparently resumed. There is considerable interest now among gas utility companies, who feel their supply situation is better than they used to think it was, in starting to connect new residential customers again.

The same situation largely prevailed with regard to commercial customers: fairly steady growth, slight dip after 1973, starting to grow again.

Industrial customers, in general, experienced much faster growth than residential or small commercial customers, but when the crunch came in 1973, the crunch hit them. There were a number of reasons for this, which I'll go into in a minute.

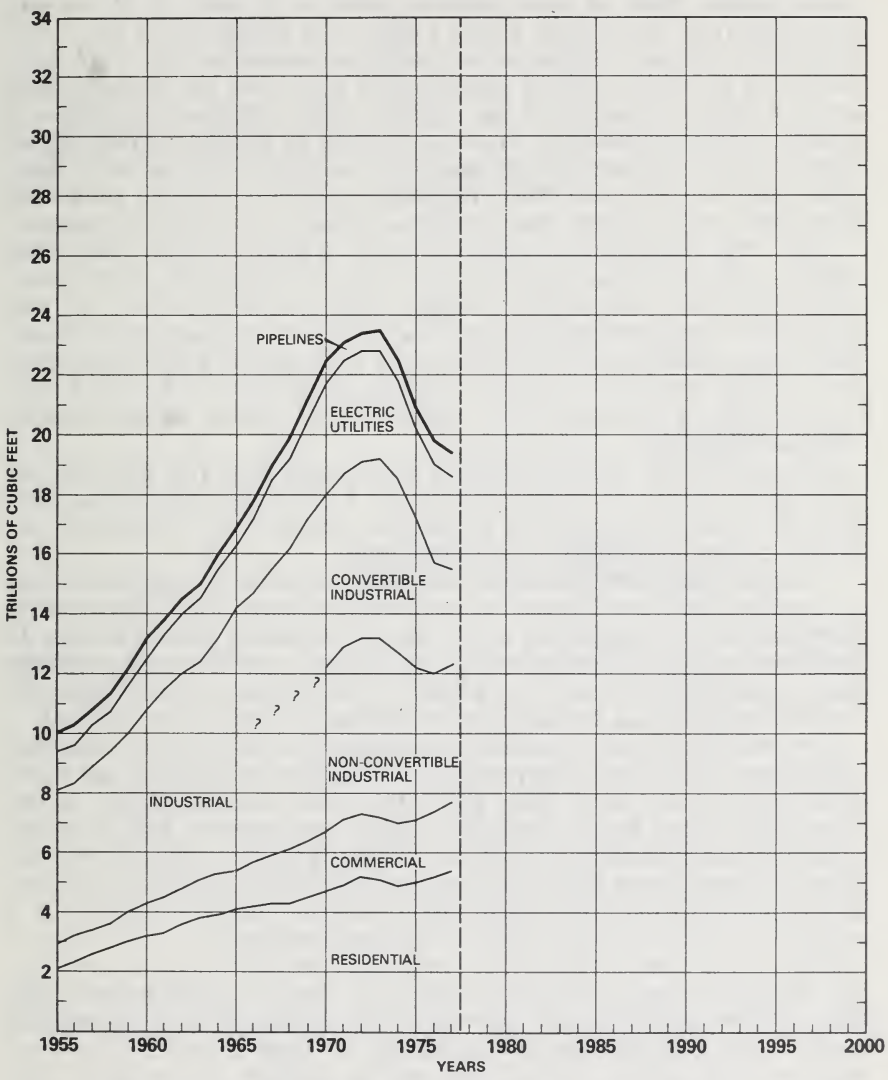
Another category of customers, electric utilties using gas for boiler fuel, grew the fastest of all. They also got crunched the hardest of all.

In general, there are a number of reasons electric utilties and industrial customers felt the crunch. First, the Federal Power Commission, in deciding who should bear the brunt of the gas shortage, determined an allocation formula. Natural gas curtailment formulas were largely based on the convertibility of the use—whether the customer could go to some other form of fuel or not for his use. And in general, residential and commercial customers cannot convert. Electric utilities, almost entirely, can convert, given time—they may not be able to convert their current boilers, but at least the use that they're putting the gas to is a use that can be satisfied by another fuel.

Industrial customers, however, actually divide into two categories. Nobody knows exactly what the breakdown is between them, so I haven't attempted to present any historical data before 1970. It's estimated that about half of the gas consumed by industrial customers, when about 10 trillion cubic feet were being delivered to them in 1973 or 1974, went for feedstock uses, process uses, other uses for which other fuels would not suffice.

The other half of the gas consumed by industry was energy that other fuels could be substituted for—at considerable expense, in many cases, and with some environmental and capital difficulties. But they were considered convertible uses of gas. Hence, the impact of the shortage has primarily been felt by the electric utilities and the convertible industrial customers. This brings us to the present, 1977. [Chart 1 reproduces the chart being drawn during the seminar at this point of the presentation.]

CHART 1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Now let's look to the future, and see what's anticipated for natural gas supplies. Most of this historical data is Bureau of Mines and American Gas Association (AGA) data. I'm going to use the AGA projections of gas supplies in two different scenarios: the AGA projection of domestic natural gas supplies with new gas deregulation, and the AGA projection of gas supplies with continued regulation. I consider these estimates at the outer bounds of reality, in both directions. I think the new gas deregulation estimate is, at the very least, optimistic, and the continued regulation estimate may be somewhat pessimistic, so it's likely that the actual situation will fall in between.

First, the deregulation estimate looks something like this (line added in chart). Then, the continued regulation estimate, looks something like this (line added in chart). For a middle ground, we can look at the Congressional Budget Office (CBO) estimate of the President's plan, which is a middle ground in pricing, and CBO found it to be a middle ground in supply response, although AGA found that the President's plan and the continued regulation yielded almost identical supplies.

In any case, the President's plan looks something like that [draws line again]. Given these general levels of available natural gas, let's look at what happens to our residential, commercial, industrial, and electric utility consumption in future years.

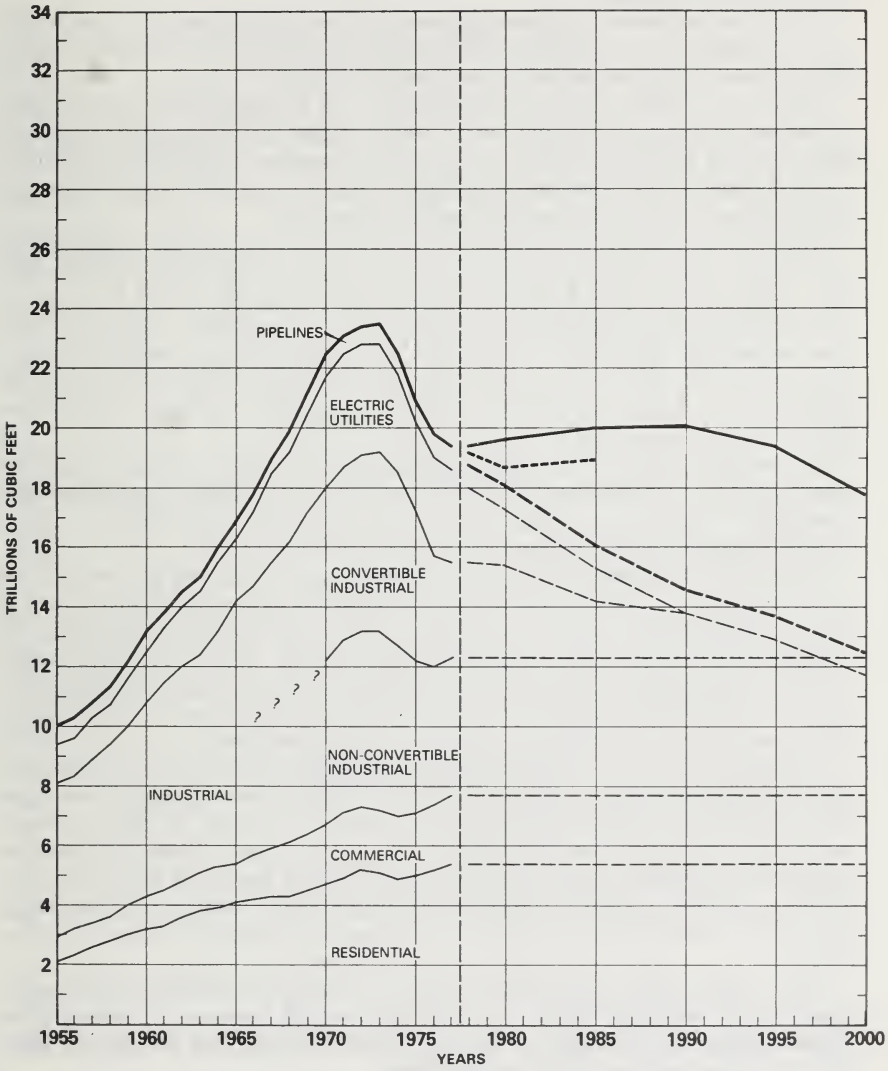
To begin with, electric utilities are being required by regulation and law, as well as by commonsense, to phase out natural gas. Reportedly, they will do this regardless of the supply situation that develops. If the lower supply scenario develops, the electric utilities will probably look something like that [line added]. If the higher one develops, the electric utilities will probably be something like that [line added].

For residential and commercial customers, if the supply situation continues to deteriorate, there will be a good deal of pressure not to let them grow. They have been growing; with some softening in the supply situation, but if available supply continues to fall as it has in accordance with these projections of supply under continued regulation, the chances are that their consumption will be fairly much level, and that would look something like this [line added]. [Chart No. 2 presents the chart at this stage of the presentation.]

On the other hand, if the more optimistic supply situation prevails, the AGA new gas deregulation scenario, then it would appear that there will be room for some growth in the residential and commercial sectors, and probably growth at about the same rate that they had been growing prior to 1973. There will be additional households. Although the population is stabilizing, the number of households, due to the baby boom and other reasons, are going to be rising over the next decade, and there will be demand for new residential units, with gas heating. There will be new residential users who will prefer to get gas if they can.

That leaves the industrial consumers. These, as you remember, are the nonconvertible industrial users. They would like very much to increase their gas usage, and they're of a higher priority than the convertible industrial gas users. But if the gas supply continues to deteriorate, it's likely that the nonconvertible industrial gas users will also

CHART 2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pretty much have to be satisfied with the amount of natural gas they are currently getting.

On the other hand, if the supply of natural gas increases, then they, too, can expect some growth. [Chart 3 illustrates the stage of the chart being drawn at this point of the presentation.]

There is a great deal of uncertainty, as I mentioned, in the estimates of what may happen with natural gas. It depends largely on Government policy, but also on natural resource availability. There's a good deal of controversy among resource experts as to what the true resources of undiscovered natural gas are.

These two attachments to the chart are depictions of the availability of supplemental supplies of natural gas of various types. These two are derived from AGA data—again, optimistic data. AGA's projections assumed no legislative obstacles, no regulatory obstacles, few environmental obstacles—in general, everything goes. Both are drawn from identical data, and vary only in the curve they fit. One can be added to the high natural gas supply scenario; the other to the low total supply projection.

If the gas supply situation is optimistic, as in the AGA deregulation scenario, for instance, then the availability of these supplementals would put total gas supply way up here [placing attachment to chart on chart above top line drawn, as shown in Chart 4].

My own judgment is that this quantity of natural gas would be considerably in excess of that demanded by those who have to use natural gas. The users who could convert to other fuels would be required to demand these supplemental sources of gas for this incremental supply to be added to the deregulation scenario. If such convertible users did not want natural gas in preference to other fuels, there would be no reason to add the supplementals.

On the other hand, if gas supplies continue to fall, in the more pessimistic outlook, this is the way those supplementals will come into play [adding second attachment to chart in place of first attachment]. As one can see, they fit much more neatly into the area of growth of existing customers who have to use gas, and they take the squeeze off the industrial customers who could convert to something else, but would just as soon not. [Chart 5 shows the chart at this point.]

Now, what is the key factor that will determine whether this package of supplemental fuels, or any supplemental fuels, will be tacked on to the natural gas available from domestic sources? I think the main factor is the incremental pricing debate.

The incremental pricing question is whether a supplemental natural gas should be sold to the end user at its full price, or whether it, like other sources of natural gas, should be averaged in with the supplies which are in the pipeline and sold to all end users at the average.

One thing which is true with regard to these supplemental sources—at least as far as future supplies go—is that each of these supplemental supplies of gas will only be available at prices above current world oil prices.

CHART 3

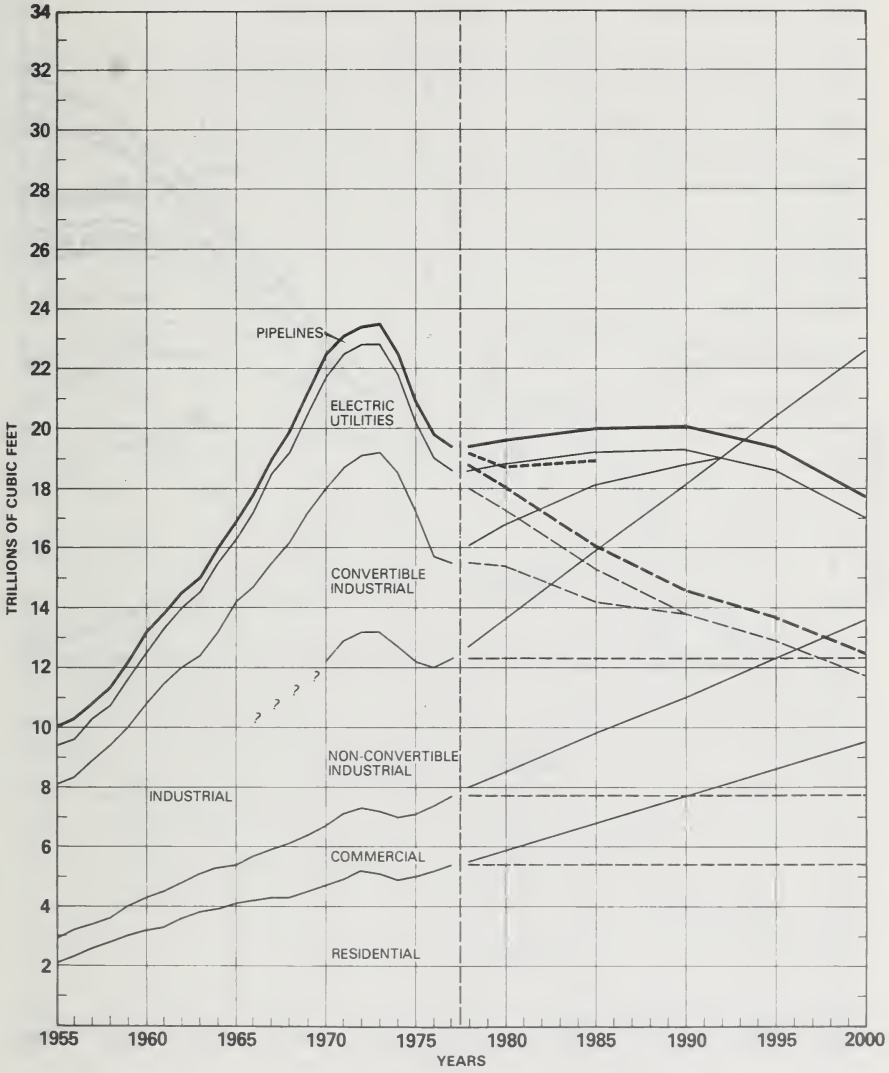

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CHART 4

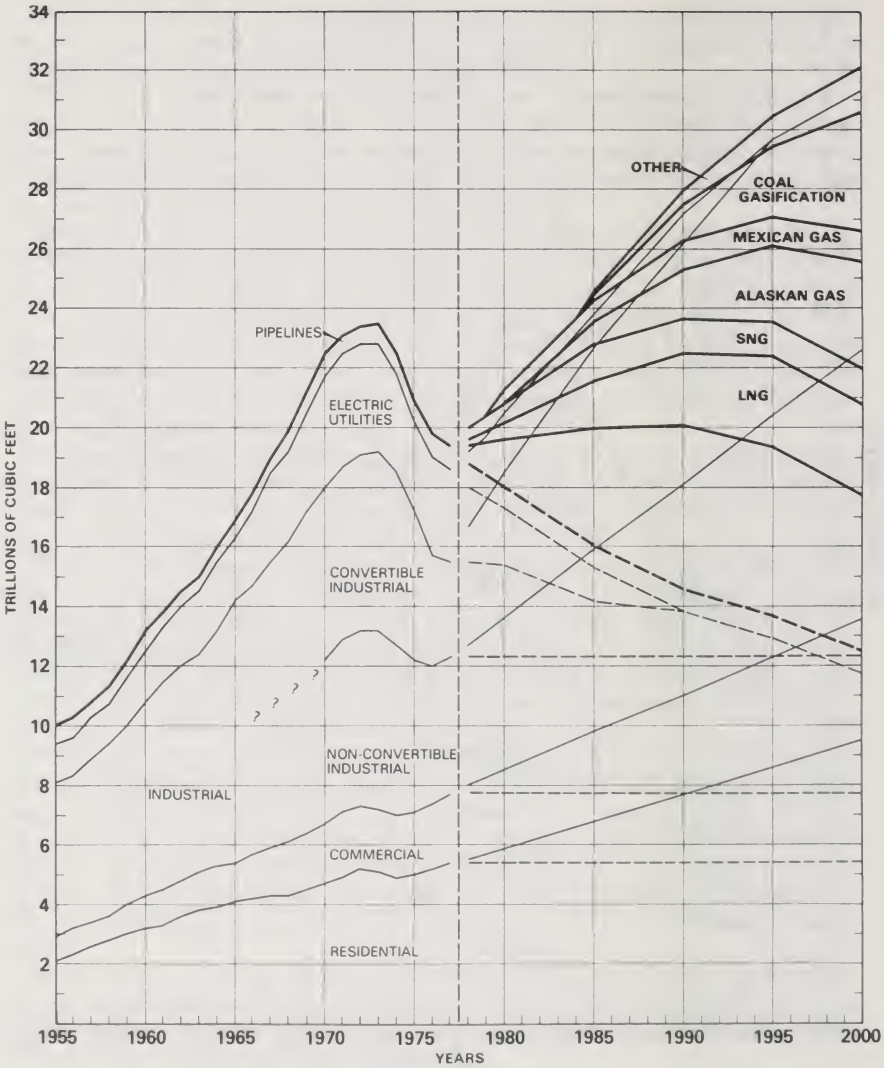
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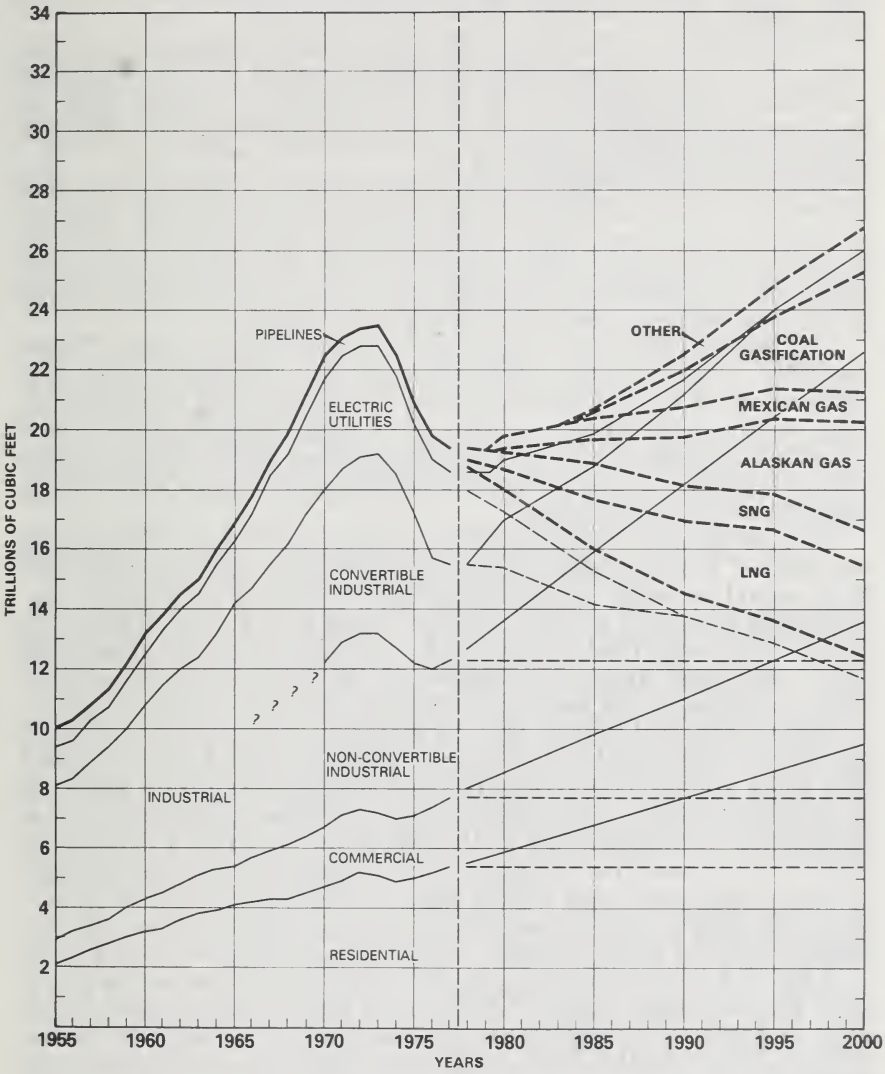
CHART 5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MEXICAN GAS
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What this means is: if priced incrementally, if this supplemental gas must be sold at its full cost to the users, customers won't buy it if they can use oil.

Looking again at the classes of users, remember that below this line, they have to have natural gas. So certainly, when you get out to here [indicating approximately 1985], there's going to be some need for supplemental supplies, assuming the natural gas situation is bleak in terms of domestic production.

However, these industrial users in this area above the blue line, and below the electric utilities—the industrial users who could convert—are the critical group. They are going to be the ones who will either decide to use natural gas and require the addition of the supplemental sources such as LNG or will decide to use world oil, LPG, other sources of fuel, or convert to coal. They have other options.

If LNG and the other natural gas supplements are priced incrementally, so that users would be required to pay their full price, that price would be above world oil prices, and users would be more likely than not to use oil. If, on the other hand, these supplements are rolled in with this entire body of flowing gas, then the rolled-in average would be below world oil prices, probably, and users would likely prefer to stay on natural gas.

Now, as the gas situation varies between here and here [indicating the area of the supplemental gaseous fuels], it's pretty obvious that there would probably be a good deal of competition among these supplemental sources of gas to determine which one or ones would be the first to become available. Public policy would presumably demand the most economical and advantageous of the various possible supplemental sources, in the event that there is demand for any of them.

There are several criteria that are going to play a part in that choice among the supplemental gas sources. As you can see, AGA anticipates that LNG would be the largest of them, given no restraints, generally favorable treatment toward all of them, followed by Alaska and coal gasification. I've made a list of 10 different criteria that I think judgments will be made on in terms of the advantages and disadvantages of one supplemental gas versus another. If we're not going to have them all, which ones are we going to have? The selection will presumably depend largely on how judgments are made on these criteria.

What I'm going to do is to go over these 10 criteria and give you some idea of where I think LNG—in my judgment, not carefully refined or based on econometric models, but just as a rough shot at it—where LNG fits in the spectrum of advantages and disadvantages for given criteria.

1. *Price now.*—In terms of the price now, it appears that future LNG projects, started now, would come in at lower prices than Alaskan gas, coal gasification, synthetic gas from petroleum, geopressurized gas, western tight gas, coal-seam methane, Devonian shale, biogas, and the other exotic sources for which the technology is not in hand.

On the other hand, my judgment, and again, it's just a rough shot judgment call, is that LNG projects started now would probably come in at higher prices than Canadian imports, which will be continuing, and Mexican imports, even at the price asked by the Mexicans.

2. *Price in the future.*—In terms of prices in the future, LNG will probably track world oil prices to some extent, because it comes from overseas, and it will be subjected to the general world energy price levels by the governments which sell it. The same will be true with Canadian imports, SNG, and Mexican imports.

On the other hand, it's not necessarily true that domestic sources of gas supplements would necessarily track world oil prices.

So, Alaskan gas, coal gasification and other sources could conceivably remain stable. Although they'll become available at prices higher than world oil prices, world oil prices over the next 10 to 15 years may rise above them, taking LNG prices along.

3. *Technology.*—The technology for LNG in my judgment is in hand. I don't think that there are tremendous additional technological breakthroughs expected or needed with LNG. Looking at the other supplementals, the technology for SNG (synthetic natural gas) is in hand, and standard pipeline technology will deliver Mexican or Alaskan gas, although with the Alaska situation there are some possible cold pipeline problems.

Coal gasification—I believe there is still some question about the technology. I think that many in the gas industry feel it's really there if you've got the money to plug it in, others feel that a technological breakthrough is awaited that could make it more feasible. For all the other sources that I mentioned, the technology is not in hand.

So LNG is on the up side, as far as technology goes.

4. *Security of supplies.*—OK, here's a tough one. In my judgment, and again, these are judgment issues, LNG supplies would be less secure than those brought through pipelines, if only for the reason that LNG can be sold—taken on a ship—to virtually any user. A pipeline is in a fixed route, with gas coming out of the well and into the pipeline; there is no practical alternative for the seller of that gas to selling it into that pipeline. He could conceivably go through the laborious process of adding a liquefaction plant, taking a number of years, or building up his own gas use, again taking a number of years. In either case, the user would have a signal for a number of years that this was going on. It would not be a surprise.

Only in the most blatant political move would the pipeline supplies be cut off. Now, that's conceivable. But, you have to remember that from Mexico, in any case, the gas is associated gas—it's being produced with the oil. If they cut off gas sales through the pipeline to us, their alternative is to burn it in the air, and get nothing for it. They could possibly reinject some, but they'll already be reinjecting a good amount, and the chances are that they won't be able to avoid wasting the gas if they don't sell it to us for political reasons. They would be losing the total value of the resource to make political mileage—perhaps not realistic tradeoff.

Canada is in somewhat the same situation—most of their gas is associated gas, although some of it is gas from gas wells. Future sources from Canada, including the Arctic Islands, seem pretty much to be gas from gas wells. But, again, our relations with Canada, while sometimes a little excited, have never been bad to the point that they would impose a political cutoff of gas supplies to us.

So, I would say that pipeline supplies are more secure than LNG, but on the other hand, I don't think that LNG is any less secure than other supplies which are brought through means of transportation which can be routed different places. In my judgment, LNG is a commodity with a roughly equal security factor, in terms of our national interest, to world oil, LPG, SNG feedstocks, and other commodities on the world market.

It's true that there is only one country from which we now import LNG, but there may soon be several more. It's also true, as far as oil imports go. Although there are a whole number of countries from which we import, there are only two or three countries who have the incremental capacity to provide additional imports. And so, in terms of growth, our security with oil imports is not much better than it is with LNG imports.

5. *Leadtime.*—In terms of leadtime, how long it takes to get a project on stream, my judgment—and again, this requires all sorts of assumptions about regulation, legislation and the rest—is than an LNG project could be gotten on stream faster than coal gasification, faster than Alaskan gas, faster than the "others," but not as fast as SNG or Mexican gas, and not as fast as the nongaseous alternatives: world oil, or LPG.

6. *Geographical points of delivery.*—Where is the gas going to be delivered? How helpful is it to have the gas where it's brought in? LNG rates very high in this. Pipeline supplies, from Alaska, from Canada, from Mexico, are going to come in away from the centers of gas consumption. Now there's large consumption at some of those points, and perhaps through displacement and such, those supplies can be assimilated and economically priced.

But in general, the flexibility that LNG has, by being shipborne, gives it an advantage over pipeline supplies. On the other hand, LNG is no more flexible than other commodities which are carried through transportation modes which can be taken wherever the commodity is demanded.

7. *Safety.*—We're going to cover the safety issue in greater extent later. My judgment is that there are more safety questions about LNG than about any of the other supplemental gas sources. I think, in terms of the nongaseous supplementals, the safety questions which could be raised about LPG (liquefied petroleum gas), but haven't, are about as significant as they are about LNG. LPG has been more widely imported into this country, and is pretty much accepted. People have it in their back yards in a little tank. They have it in their campers. They're used to LPG, I don't think it raises the public sense of danger that the idea of LNG has so far raised. My personal judgment is that the LNG safety issue will remain a major issue, and perhaps displace nuclear safety as the energy safety issue of the eighties.

In any case, among the other gas supplementals, I don't see any effective safety problems except for the OSHA type problems with the pipeline supplementals, or SNG. In coal gasification, there are environmental problems or emissions of substances that could be carcinogenic and such—that's a safety problem of a different sort. The other gas sources are not known well enough to really know what the safety problems are. There could be safety problems with those, but

in general, my judgment is that the LNG safety problems are the most significant among the supplemental sources.

8. *Future availability.*—LNG availability over the long run I see as better than that of fuel oil. LNG availability is not going to peak out in the eighties, which is what the CIA says fuel oil will do. LPG, because of its simpler technology, will probably be running about even with LNG in terms of availability, and better than gas from Alaska, from Mexico, or SNG, and perhaps some of the others.

Coal gasification? Well, we've got an awful lot of coal. If we get into gasification in a real way, who knows what to say about its availability? I think there's no chance that coal gasification will actually supply more supplemental gas to the United States than LNG, and would probably never do that for 150 years if neither of them were blocked by regulation or legislation.

The other two factors I wanted to mention are capital investment and environmental effects.

9. *Capital investment.*—In capital investment required, I see LNG as better than coal gas and Alaskan gas, but not as good as LPG, fuel oil, SNG, or Mexican gas. But on the other hand, LPG, fuel oil, and Mexico is a larger amount of foreign investment, whereas the LNG investment, a substantial part, would be domestic investment, and has those benefits attached to it.

10. *Environmental factors.*—It's a pretty close call with most of these. I don't think the environmental impacts of many of the supplemental gas projects are going to be significant except in the case of coal gasification. I don't believe that LNG is going to have significant deleterious environmental impact, but it's not going to be that much better than the others, either.

So, given these criteria, people are going to be making their judgments among these supplemental gas sources to the extent that the gas supply situation requires supplemental gas sources.

MODERATOR. Our next speaker is Dr. Warren Donnelly of the Congressional Research Service. He's going to briefly review some of Congress' past concerns with respect to LNG safety.

C. Review of past and present congressional interest on LNG

Dr. WARREN DONNELLY. We're pouring it on hot and heavy this morning. In China it's the year of the horse, some people think that in Congress it may be the year of LNG, at least if some who are raising questions about LNG succeed in sensitizing Congress.

I've taken a look at what Congress has done about the hazards of liquefied natural gas, particularly those associated with marine transport, and indications of this congressional interest. What I have to say is based upon a report that we have prepared to supplement the report of the General Accounting Office. Our analysis started as an experiment in interagency cooperation with the GAO. We had hoped to come out with something jointly. For various reasons, the joint effort fell by the wayside. So, we now have this CRS report, I have copies here, and we trust that Mr. Rosenbaum and GAO will find it of some use, and also Members of Congress and committees. [This CRS report is attached as appendix I.]

Probably the most important evidence of congressional interest in the control of hazards from the marine transports of LNG is to be found in the still incomplete and partial legislative foundation for its regulation, a foundation which was created largely for other reasons.

We find some nine statutes, already on the books, that deal directly or indirectly with the control of LNG hazards from ships and shore terminals. Of these, two deal with natural gas, one with siting of facilities, four with marine transportation, and two with protection of the environment. Taken together, these provide authority and opportunity for Federal action by the Federal Energy Regulatory Commission and the Department of Energy, the Department of Transportation and the Coast Guard, the Council on Environmental Quality, the Environmental Protection Agency, the U.S. Army Corps of Engineers.

However, none of these statutes provide for coordination of the exercise of these scattered authorities. I have identified and briefly summarized these statutes in my paper.

Now, looking beyond the existing statutory base, we find indications of congressional interest in bills that have been introduced, special reports delivered to the Congress, hearings that have been held, and items which have been put into the CONGRESSIONAL RECORD. If we look at all these items, we discover that since the LNG explosion in 1944, there really has not been a great amount of congressional interest in the hazards of LNG. And the interest which has occurred has been rather sporadic, and has risen and fallen in response to external events.

I think it's particularly interesting, for example, that there were no hearings at all on the 1944 accident. Of course, this was during World War II, but nonetheless, if that accident had taken place today, you can imagine the kind of hearings that would be taking place.

So, let's take a look briefly at bills which have been introduced, that could directly or indirectly relate to safety of LNG transport by sea. During the 1970's, Members have introduced some 13 bills, which is not a great flow of bills. Six of these dealt with siting and construction of LNG terminals. Three would have established an LNG tanker fleet, one of the early responses to the Arab oil embargo of 1973–74. One had to do with Department of Transportation control over LNG transportation. One had to do with LNG safety, and two with economic aspects of LNG. None of these 13 bills were enacted into law.

If we look at advice that Congress has received, and here now, I'm looking only at advice that Congress has asked for, because there's been a great flow of analysis and information and opinion from the trade associations and environmental groups, and others. If we look at reports that originated with a congressional interest, we find five of them during 1975–77. Of these, two had to do with the Alaska pipeline, one of them being, of course, the Federal Power Commission's report, on the various routings, which was a requirement of Congress, and one having to do with the President's own report, in which he recommended his choice, and that too, was a requirement of Congress. Two reports were prepared by the Comptroller General, these were

largely self-initiated, and one by the Office of Technology Assessment, which was a direct response to a congressional request.

If we look at these reports, we discover that the two most recent ones, the Federal Power Commission's report, and the President's report, deal only very indirectly and in a minor way with hazards of LNG. The hazards are mentioned, a few words are said, and that's it. The GAO reports, to date, concentrate on economic, foreign policy, and economic matters. They do mention hazards somewhat, but once again, they do not go into it in any depth.

The OTA report to Congress, presents quite a bit of information, but it rigorously stays away from the question of what would be the maximum credible accident, by saying we don't know enough to lay it out—at least not to lay it out in the way that the Atomic Energy Commission tried to lay out the maximum credible effects of a catastrophic nuclear accident.

These five reports are part of the literature of the special analytical input into the Congress. They certainly have some importance in what Congress may do and how Congress may react concerning LNG this year.

If we look at congressional hearings on LNG, since 1967, there have been eight hearings by various congressional committees. These include two Senate committees, the Commerce, Science, and Transportation Committee and the Interior Committee, which is now the Energy and Natural Resources Committee, two House committees, Merchant Marine and Fisheries Committee and the Interior Committee.

Most of these hearings touched on LNG hazards tangentially, incidental to other purposes, such as land use, environmental impact, economic and foreign policy. The hearings that got closest to LNG hazards were House hearings where questions were being addressed to the Coast Guard. But even here, the thrust was more on coordination—who's responsible for doing what to assure LNG safety—with comparatively little attention to how serious is the risk. Typically, some witnesses said the risk is serious, and others said it was not.

I have identified and summarized these hearings in my report [app. I, p. 57]. Out of this came one congressional report in 1974, by a subcommittee of the House Committee on Interstate and Foreign Commerce. It reported on the Federal regulatory system dealing with LNG storage facilities, based upon hearings held following an accident at an LNG facility on Staten Island in March 1974, where there was an explosion. Although we should point out that it was not established that the explosion was an LNG explosion.

Here we find a subcommittee of the House Committee on Interstate and Foreign Commerce, reporting on legislative issues relating to the safety of LNG storage. To give you bit of the flavor of what the subcommittee said in 1974, I would like to quote it briefly. The subcommittee said:

> Congress can resolve much of the jurisdictional conflict between the OPS and the FPC by amending the Natural Gas Pipeline Safety Act to establish the OPS with exclusive authority to impose safety regulations on pipeline facilities including LNG. But the issue will not be laid to rest as long as the FPC retains arguable authority to translate its own safety judgments into conditions for the certification of particular LNG facility siting routes * * *

Continuing in this vein, the subcommittee underscored the jurisdictional problem, which is the one most likely to get congressional attention. Although, under the reorganization, the new Federal Energy Regulatory Commission has taken over some of these Federal Power Commission functions, the jurisdictional issue remains unresolved.

The subcommittee urged resolution of the problem of vague jurisdictional responsibilities of the Office of Pipeline Safety (OPS) and FPC, and said that that resolution would be a major step toward centralizing responsibility for safety, substantially simplified and more orderly certification, and, in the long run, more effective administration. Since then, nothing much has happened. Agency committees were formed. When these agency committees appeared before congressional committees, the most they could do was to explain why they were not able to reach agreement.

If we look finally at the Congressional Record, we find that from May 1969 to November 1977, 13 Members of Congress made statements or placed materials in the Record relating to LNG hazards. Of these, five were in support of bills proposed by Members. Now, considering the enormous amount of other materials in the CONGRESSIONAL RECORD during these 8 years, these few items would indicate correspondingly little general congressional interest to date in the control of LNG hazards. I have identified those items appearing in the Record in my report.

Now, where does all this leave us? On the whole, I think the situation is typical of so many of the matters that are before Congress; unless there's something around that propels these matters up out of the soup of unfocused legislative attention, nothing much happens.

There has been sporadic low-level interest by Congress in the safety hazards of marine transport of LNG, but it has not been as sustained as congressional interest in, say, the hazards of nuclear energy, or the hazards of black lung disease in coal mines.

At this time, then, if there were to be any significant legislation before Congress relating to the safety of marine shipment of LNG, a substantial effort would be required to prepare the Congress to act on such legislation. That, in my estimation, is where we stand today.

D. Review of major LNG legislation and issues before the 95th Congress

PAUL ROTHBERG. Thank you, Warren, for reviewing the past congressional interest on LNG. The purpose of my talk will be to provide an overview of some of the major issues concerning LNG that are of concern to the 95th Congress. I will then relate these issues to some of the bills that were introduced in the first session of the 95th Congress. Finally, I will list and discuss some possible opportunities for further congressional attention.

On the following chart, I have presented a matrix which compares major provisions of the legislation before the 95th Congress to a list of issues associated with the importation of LNG.[1] Bills are listed on the top portion of the matrix; issues are listed on the left side of the matrix. Wherever a provision of a bill is relevant to an issue, an "×"

[1] The reader is referred to app. II for additional details on these issues.

is indicated. Thus, this matrix compares major provisions of the legislation before the first session of the 95th Congress to a list of issues concerning the importation of LNG.

LEGISLATION INTRODUCED IN THE FIRST SESSION OF THE 95TH CONG.

Major issues	H.R. 9731	H.R. 9773	H.R. 6844	S. 2273
Pricing of LNG				
LNG import levels			X	X
Federal regulation of LNG import systems			X	X
Safety of LNG systems			X	X
Offshore siting of LNG systems				
Onshore siting of LNG facilities	X	X	X	X
Federal versus State authority pertaining to the siting of LNG facilities	X	X	X	X
Research and development on LNG systems			X	X
Compensation and liability concerns related to LNG accidents			X	X

I have listed nine issues on this matrix. We've already talked about LNG pricing and LNG import levels, so I'm going to skip the first two issues and start with Federal regulation of LNG import systems.

There are numerous Federal agencies that are involved in the economic and environmental regulation of LNG receiving, storage, regasification, and shipping operations. The current Federal regulatory system governing these facilities is, by necessity, rather elaborate, complex, and involves many parties. This regulatory system, according to many industry officials, is extremely complex and cumbersome. Numerous Federal, State, and local permits and regulatory approvals are required for an LNG receiving terminal and its associated facilities. Studies have shown that delays in obtaining approvals from these agencies have slowed the innovation of many projects, and have contributed to the cancellation of others. In addition, delays in obtaining regulatory permits are a contributing factor to escalating costs for LNG facilities and operating expenses. Some of these costs are eventually passed on to the consumer.

The Federal regulatory system also causes problems for the U.S. competitive position in the international LNG market. Potential suppliers of LNG may turn toward countries that have a more reasonable and flexible regulatory system (in terms of getting an LNG project into place), than currently exists in the United States.

As Dr. Donnelly mentioned, there has been some congressional attention on the Federal regulatory system, from the viewpoint of safety. Congressional attention has also focused on jurisdictional gaps, overlaps, and disputes between Federal agencies. For example, a subcommittee report of the House Interstate and Foreign Commerce Committee found that overlapping regulations on LNG storage safety have lead to duplication of effort, fragmentation of responsibility, and inefficient administration. These qualities do not appear to be compatible with the optimal requirements one would want for a system that must regulate LNG operations. It seems a contradiction in terms to have a very inefficient and fragmented regulatory system for maintaining the safety of such a potentially dangerous material, as is LNG. A review of the Federal regulatory system is a possible area for further congressional attention.

The next issue listed on the matrix pertains to LNG safety. I'll summarize this by saying that there are many potential hazards posed by the importation of LNG. I'll leave a detailed discussion of this subject to Donald Allan of Arthur D. Little, Inc.

However, it needs to be pointed out that the LNG import industry does have many accomplishments to its record in terms of safety. These include the LNG tankers that have recorded more than 3,100 successful voyages without incident, and the more than 60 LNG peak shaving and satellite plants operating in the United States and Canada, which have a relatively safe operating record. As the Congress examines the safety of the LNG industry, it might be useful to consider some of the potential hazards of LNG in relationship to the safety history of the industry.

Another area of concern—this is really the next three issues shown on the matrix—pertains to the siting of LNG terminals. One issue focuses on the questions: Can we site an LNG terminal outside the 3-mile State coastal zone? Can offshore LNG facilities be legally sited? Then we have the question of where shall we place LNG terminals and facilities on the continent of the United States. And there is yet another part of the siting question. This dimension pertains to Federal versus Sate rights—where is the line drawn, and who has the final say on where an LNG facility will be placed? These are all areas of uncertainty that may require further congressional attention.

With respect to siting, at present there is no Federal siting policy to govern the location and size of LNG plants throughout the United States. It's a tremendously difficult and complex decision on where to site an LNG facility. Do you put an LNG terminal in a rural area, an industrial area, or a residential area? There are all sorts of tradeoffs and problems pertaining to safety, economics, and environmental impact. This is a question which all the bills in the 95th Congress address in different ways.

Some of the unresolved questions pertaining to siting include, should new LNG import facilities be located only in remote sites? And then, the next question is, how do you define a "remote" site? Should the Federal Government, local communities, or State governments establish LNG facility siting criteria? Should the Governor of a State be allowed to veto a Federal decision pertaining to siting? What role should the public have in the determination of a siting decision? These are some of the questions that the legislation is beginning to address.

The next issue, down the line, pertains to research and development on LNG systems. There's a number of Federal agencies that are doing bits and pieces of LNG research. NASA's involved, as well as the Coast Guard, and the Department of Energy. Whenever there's an array of different Federal agencies involved in a research-and-development effort, there immediately arises the question of coordination, namely, who should be the lead agency? Then there is the question of overlap, and this is an area that some of the legislation before the 95th Congress begins to address. The research-and-development question is particularly timely, because the authorization and appropriation process is now proceeding through Congress.

The last area pertains to the question of what happens if there is another LNG disaster. Who will pay the damages? What types of

compensation and liability responsibility exist? This is another area of uncertainty that some of the legislation is beginning to focus on.

Now, as far as the legislation is concerned, I've selected four bills that I think are representative of what's been introduced thus far. There are two "broad" bills that deal with a number of different issues. One was introduced by Senator Pell (S. 2273); the other by Mr. Dingell and Mr. Markey (H.R. 6844). And then there are two "specific" House bills (H.R. 9731 and H.R. 9773) which deal primarily with the question of States rights in siting issues.

I will just briefly mention a couple of the provisions of each bill. I suggest that if you want to obtain a more comprehensive and accurate understanding of this legislation, you ought to review the original bills.[2]

Mr. Pell's bill (S. 2273) gives the Secretary of Energy jurisdiction over construction permits and operating licenses for LNG facilities, and directs the Secretary of Energy to promulgate such regulations as may be necessary to establish minimum standards for the location, design, operation, and construction of LNG facilities. S. 2273 provides that after June 30, 1977, an LNG facility cannot be constructed without a permit issued by the Secretary.

Under the terms of S. 2273, in order for the Secretary to issue any LNG construction permit, the Governor or a responsible agency of the affected State must approve the specific location of the proposed facility. However, the bill allows the Secretary to issue a construction permit without this approval if the Secretary determines that the LNG facility at the locations specified is necessary for national security reasons. S. 2273 mandates that a hearing be held in the affected local district on an application to build an LNG facility.

Mr. Pell's bill (S. 2273) places a new responsibility in the hands of the Secretary of Energy—to promulgate such regulations as may be necessary pertaining to minimum standards for LNG facilities. This can be contrasted with Mr. Dingell's and Mr. Markey's bill (H.R. 6844), which places this responsibility with the Secretary of Transportation.

Mr. Pell's bill (S. 2273) directs the Secretary of Energy to report to Congress his recommendations concerning creation of a compensation and liability fund to protect the public against risks associated with the construction and operation of LNG facilities. In contrast, Mr. Dingell's and Mr. Markey's bill (H.R. 6844) states that a permit may not be issued unless an adequate contingency plan setting forth such steps to be taken in the event of an LNG accident is provided. In addition, assurances must be given that there is adequate financial coverage to satisfy the claims for personal injury and property damage resulting from the most severe LNG accident which could be expected. These bills illustrate different perspectives on where LNG legislation is headed.

Some of the other provisions of H.R. 6844 pertain to how close to a residential area can an LNG facility be built. There are also provisions pertaining to the population density and the siting of an LNG facility.

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[2] For additional details on these bills, the reader is referred to app. III.

Mr. Pell's bill states that the Secretary of Energy, in consultation with other Federal agencies, must report to Congress on the adequacy of current Federal research and development efforts related to health, safety, and environmental control in connection with LNG facilities.

The other two bills, H.R. 9731 and H.R. 9773, basically state that the Governor of the State, or in some cases, also the legislative body of the State in which a proposed LNG facility is to be located, has to approve in writing this facility. These bills are of special concern to a possible siting problem now occurring in the State of Rhode Island. Part of the problem is concern over States rights versus Federal preemption authority.

So, in conclusion, as I see the situation, the executive agencies and the President have made many of the major decisions concerning the emerging LNG import industry. Although these decisions will affect millions of gas consumers, the role of Congress has been very limited, especially in the areas of safety, siting, and pricing.

The bills that have been introduced thus far are still in the early stages of the legislative process, and are somewhat preliminary and for discussion purposes. In their current form, these bills would continue the Congress limited influence on many of major LNG policy concerns.

For example, none of the bills would give the Congress a major input in deciding whether LNG should be incrementally priced or rolled in. These bills do not provide the Congress with a major input in deciding how much LNG should be allowed into the United States. The question of offshore siting of LNG facilities is, in my reading of these bills, unaddressed.

If the Congress decides that the LNG industry requires additional attention, review, and oversight, the timing of future congressional actions is very important. Many of the major decisions pertaining to the LNG import industry have already been made. Several major LNG facilities are already at the final stages of the regulatory process.

There are opportunities for a wide range of congressional actions concerning LNG. Congress could examine the need: (1) to improve the Federal regulatory system, (2) to strengthen and expedite Federal research and development on LNG, (3) to design a Federal siting policy for LNG terminals, (4) to create an LNG damages or compensation fund, or (5) to maintain an active role in setting LNG pricing and import policy.

Or, there's always the option of continuing the *status quo* in the way the Congress has handled LNG concerns in the past; that is, from time to time overseeing the process. Thank you.

Peter Hunt. I'd like to point out that from the standpoint of sources of information on the part of Government work that has been done—I think the Federal Power Commission record, particularly in the area of the *Distrigas* case heard by Nuham Litt, roughly 3 years ago, has the best examination, to my mind, of any Federal work relative to safety.

I think the record ran to 6,000 pages, generally focused on the issue of safety. It's quite a complete argument. I won't say it's easy to access, but it is there.

Part II. OTA Report and LNG Safety Concerns

Moderator. Our next speaker is Peter Johnson, of the Office of Technology Assessment. He's going to concentrate on the Federal regulatory system, Federal siting policy pertaining to LNG facilities, and several other areas. He will selectively review parts of the Office of Technology Assessment's study on the "Transportation of Liquefied Natural Gas."

A. Overview of OTA's assessment entitled "Transportation of Liquefied Natural Gas"

Peter Johnson. The Office of Technology Assessment completed a study in September of last year on the transportation of LNG. The study was requested by the Senate National Ocean Policy Study, and it was done over about a 6-month time period. It focuses on the national concerns about the technology to import and transport large quantities of LNG in this country in the future.

I'll present a summary of the report, and highlight some of the subjects involved in it—some of the subjects that haven't been covered by the other speakers here today. Many of the speakers covered subjects which we also have included in our report, as well.

The OTA study addresses the present and future consequences of introducing such technology as planned for a series of major U.S. LNG import projects. The operational phase of the first of the projects will begin this year, as Max Levy has told you about. Similar systems are also planned for bringing some Alaskan gas to the Lower 48, so these are included as well.

The report contains three principal chapters and several appendixes. The first chapter describes the LNG system of ships, terminals, storage tanks and connecting links; the history of LNG; and the status and trends of present projects. This chapter addresses the likely future deployment of LNG technology in the United States, and describes how the history may relate to some future trends.

The second chapter in this report is a series of nine papers. They contain critical reviews of subjects or issues which we identified as those of some considerable public concern. The subjects of the critical review papers briefly are: First, the design and construction of LNG tankers, including the adequacy of standards, the safety record of tankers in the past, and the future trends in tankers. Second, regulation and inspection of tanker operations, including traffic control systems, the Coast Guard inspection practices, and crew training.

Next, there is a paper on the regulation of terminal operations, both in the area of setting design standards, enforcing those standards, and inspecting the operations. This paper also includes the process of arriving at a decision to allow a project to proceed, which, as you know has in the past been principally an FPC matter, now under the jurisdiction of the Department of Energy. In the same paper are considerations of LNG import policy, and coordination among the regulatory agencies involved, that is, the Department of Energy, the U.S. Coast Guard, and the Office of Pipeline Safety Operations.

Another paper is on the research work by the Federal Government, leading to a determination of the acceptable safety of LNG operations.

That paper describes some of the past work on safety and looks into the suitability of risk-analysis techniques that are used. You'll hear more about the safety question from our next speaker. Originally I thought David Rosenbaum from GAO would be a speaker here today, because we deliberately included references to the GAO work on safety, and excluded some of the more detailed studies on the safety of terminals, and other aspects of research, because the GAO was already doing a study on that subject.

Another paper is on the process of siting LNG facilities, including the questions of who should, if anyone, establish siting criteria, and what criteria should probably be considered.

Another paper is on the present status of liability for LNG accidents.

The next paper is on the relative reliability of LNG supplies from countries such as Algeria and Indonesia—who are the prime sources of the presently planned projects, and also discussion of some countries who may be suppliers in the future, for projects just now in the talking stage. This paper includes an analysis of possible regional dependence on imported LNG, when the presently planned projects are operational.

And last, there's a paper on the determination of LNG pricing policy.

The final chapter of our report describes public concerns about LNG and actions desired by certain groups, such as utility companies, labor unions, State and local officials, related industries and public interest groups. We based this discussion on information we developed during our study by means of panel and workshop meetings, and interviews and mailed questionnaires to various persons and groups interested in this subject.

As you know, the technology of handling LNG on land has been in use in this country for over 20 years, and in fact, the first LNG peak shaving facility which suffered an accident in Cleveland in 1944 was in operation over 30 years ago. Also, the transportation of LNG from port to port in special tankers has been around for many years. The Algeria to United Kingdom trade has been operational since 1964, the Alaska to Japan trade since 1969, and even Algeria to Boston trade since 1971.

However, to date, the United States has not been a major importer of LNG, and new projects underway will make a major change in that situation. By 1980 to 1985, our estimate is that it's likely that about 5 percent of the natural gas that is consumed in this country could be imported in the form of LNG.

It's also possible that newer LNG projects, just in the early planning or talking stage, could raise that percentage to about 15 percent in 10 years following. These are just general guidelines for the amount of LNG that might be in use in the coming years.

One could argue that the future will not bring a major increase in the scale of ships, and storage tanks, from those in use today, and in fact, the size of the ships has become rather standard, about 125,000 cubic meters, and in fact, some of the big storage facilities, such as the one you saw at Cove Point, is really no larger than some peak shaving storage tanks in a few of our large cities today.

However, from another point of view, today a very small amount of LNG is being transported within the waters of Boston Harbor, and Kenai, Alaska. In a few years that amount could grow by a factor of about 20, and each day, on the average, about 200,000 cubic meters of LNG could be in transit, in U.S. waters, in places such as Boston, Chesapeake Bay, Savannah River, Lake Charles, La., Matagorda Bay, Tex., somewhere in California, and Alaska.

The safety of these operations are naturally of concern to many. Even though to date there have been a few serious problems with either LNG ships or terminals excepting incidents like the Cleveland accident, and the accident at Staten Island. However, even the remote possibility of a very serious accident deserves attention, because the consequences could be severe.

Large spills of LNG on land or water behave in different ways, but each could cause major fires after evaporating and mixing with oxygen in the air. An LNG spill on water would quickly spread and evaporate, probably much faster than a spill on land. A large cloud would probably form, and if it were ignited, it would burn very rapidly. You'll hear more about clouds and fires and explosions from the next speaker.

But, the important considerations are, first, LNG is a dangerous cargo—perhaps not the most dangerous—but it is dangerous. And it could cause major problems if an accident did occur. And second, the U.S. picture of LNG transportation is growing rapidly in the future.

I'll discuss some of our particular findings related to the regulatory aspects and possible future problems that we investigated. Under the subject of tanker design and construction, we studied the U.S. Coast Guard's operation of specifying and enforcing design standards for U.S. ships and foreign ships. This included the Coast Guard's letter of compliance program, which is a system they use to evaluate the standards that the foreign-built tankers are designed and built to.

It appears that the low risk of the tanker operations in the past, and the good safety record of LNG tankers is related to the standards that have been promulgated and are in use today, and it is our general judgment that would lead to a fairly low risk operation in the future.

There are a couple of questions under tanker design and construction though, that we had some cause to question. One has to do with the size of tanks and the size of the ships themselves. In the future, there may be some incentives to increase ship size, and since the possibility of a major collision, penetrating cargo tanks does exist, even though it may be a remote possibility, it may be a good idea to look into a limitation of tank sizes or ship size. The other concern that we had in the construction area, was that as the fleet grows older, it seems that greater caution and attention should be paid to determining how well the ships will be maintained. This would include how well cargo containment systems, that in some cases are fairly new designs today. will hold up over time—how well inspection and monitoring of all ships will be done—how well the foreign flag states will also survey and inspect their ships.

In the area of tanker operations and regulations, one of the things that was brought up earlier that we did investigate was the problem of traffic monitoring and control. As you probably know, the Coast

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Guard now has regulations to limit other traffic in Boston Harbor, the one place where we are importing some LNG today. They establish a clear harbor, and regulate shipping to the extent that no other marine traffic is allowed when a ship enters the harbor.

Each LNG terminal has unique traffic problems, and the system that's operating now in Boston Harbor probably won't work the same everywhere. The adoption of positive traffic control systems is a possible measure that the Coast Guard could take under present authority. Some ports do, in fact, have vessel traffic systems in operation, but in fact, none of the ports that are now importing or plan to import LNG have any vessel traffic system.

Criteria for establishing vessel traffic systems have been used by the Coast Guard, based on the number of ships and accident records in each harbor. It seems that additional criteria may be also used including how hazardous the cargoes are, and what potential impacts of major accidents may be in certain harbors.

Under the subject of tanker inspections—as you know the Coast Guard inspects LNG ships as they enter this country, and they have a boarding program operating in Boston, in which they board the vessel, the *Descartes*, each time it enters the harbor, look over the cargo systems, and also, escort the vessel into port; when they have determined that everything is operating properly.

Their inspection, however, doesn't include any of the propulsion systems on the ship, or the navigation equipment, or even determination of crew competence. We suggested that possibly more rigorous inspections could be utilized in the future, and that inspector training and inspection technology that's used could be improved.

On the subject of the training of crews, we have been impressed by the fact that the industry has done a remarkable job in training their crews, and they apparently have a very good system. However, the Coast Guard standards for crews have two different aspects to them. One has to do with U.S.-flag ships, and another has to do with foreign flag ships.

The Coast Guard has proposed standards for U.S.-flag ship operations, and presently is working with the international community to gain the same acceptance of standards for foreign flag crew competence. This is a long process, and there may be some reason to think that improvements in promulgating standards in foreign flag ship operators may be useful.

On the subject of the regulation of terminal operations, the present regulations are promulgated by the Office of Pipeline Safety Operations, in the Department of Transportation and to date they have adopted industry standards developed under the National Fire Protection Association, and those standards are in force.

There is now a proposal from the Office of Pipeline Safety Operations, for new standards, with some new coverage in them. Some of the new coverage includes thermal exclusion zones, vapor dispersion zones, and seismic criteria.

We have noted that there have been concerns by industry that these standards are too stringent and do not allow enough flexibility for their operations. Buffer zones for vapor dispersion in these proposed standards could require companies to acquire very large areas around

LNG storage tanks. One of the alternatives to large buffer areas in the proposed regulations is that one would have an automatic ignition system for lighting a fire on an LNG spill if it occurred. There is quite a bit of controversy about whether that's a reasonable alternative or not. Or whether there are other alternatives that might be preferable.

On the other hand, the proposed standards do not seem to specify some of the design and construction details that the industry had specified in the past, such as, equipment specifications and material specifications.

Another subject is the actual inspection, and enforcement of these standards in terminal operations. There appears to be some gaps in the current inspection process. The Office of Pipeline Safety Operations does not have an inspection staff of a very large size, and they in fact have not been able to do LNG inspections themselves. They have made agreements with the State agencies to adopt their standards, and carry out inspections. These inspection programs do vary among the States, and in some cases they are not as good as others.

It appears that the Office of Pipeline Safety Operations could include guidelines of inspection and enforcement, along with standards, and there may also be some reason to think that guidelines for training inspectors themselves might be useful.

There are some other coordination problems among the agencies. In the past the FPC has made stipulations at various hearings for companies to follow when they design, build, and operate a plant. It doesn't appear that the FPC does any enforcement of their stipulations. And its difficult to see in some cases that those regulations that the FPC has made are enforced by anyone since the Office of Pipeline Safety Operations doesn't have the staff and the information doesn't always get around very well.

The last subject I'll cover is LNG facility siting which is basically a very controversial subject. It's related to safety, but it's also related to environmental concerns and land use questions.

We looked at who should establish criteria, if any, and what criteria should be considered. And even how one goes about defining a remote site, if that's one of the criteria. To date, the industry has selected sites, and the Federal Government has appraised those sites. In past cases that have been considered, there has not been a lot of local participation in this process of site selection. And we found that the Federal process has not really encouraged local participation.

Many groups have suggested that the Federal Government set site screening standards, or establish some uniform siting criteria. In the past the FPC was asked by a group of Eastern States to establish siting criteria—this was almost 2 years ago. The new Office of Pipeline Safety Operations regulations also include some siting criteria. Some of the regulations in fact, do determine what sites may or may not be allowed. The Coast Guard also has a say in siting. They naturally determine what ships may operate, whether or not a ship has access to a site. But they have not taken part in any siting criteria determination, and in fact have tried to stay out of the subject.

In our report we offered some options one might consider on establishing siting criteria. I'll present just some of these options. We thought that perhaps an approach in three parts would be useful. The

first part would be standards. Those standards might include things such as property dimensions and distance from storage tanks and terminals to other property lines. And the conditions of habor entrances, shipping channels, turning basins, and tanker berths, and the relation to other marine and land use activities in the region. The standards could also cover impacts on natural resource values, and presence of unusual hazards like seismic problems.

The second part that could be considered has to do more with planning of future LNG import projects. This would include a definition of the existing natural gas pipeline network, the projected demand for the use of gas through those pipeline networks, and the projected domestic supply of gas through those pipelines. In addition the possible source of foreign countries with excess gas to export would be set out in a plan. Siting guidelines could be a third part to consider. Guidelines could cover items such as location of a site relative to dense population centers, and resolution of land-use conflicts. Also, the location of the terminal relative to other ship traffic, benefits to specific industries and satellite developments, and questions of degradation of natural areas, or residential areas, by introducing industrial activities.

The location of population exposed to specific accident scenarios at a terminal would be included as well as the presence of external factors, like severe weather and nearby airports, and availability of equipment to control effects of accidents.

This concludes my remarks. I've just briefly covered some of the points that are detailed in our LNG report. The report is available to anyone who would like a copy.

Moderator. Thank you. Pete. Our next speaker. Donald Allan, of Arthur D. Little, Inc., will concentrate on LNG safety concerns. ADL has done work for both industry and for government and is very respected in the scientific community. We're glad that Mr. Allan could come at very short notice.

B. A brief summary of LNG safety

Donald Allan. Research and engineering evaluations of the safety of LNG facilities and operations are extensive. In fact, they are continuing with new, comprehensive programs now being planned. This effort is predicated on the desire of both industry and the Government to insure that the risks presented by existing and planned LNG projects are acceptable. In general, the effort reflects a public concern with the adequacy of LNG safety.

To present a balanced and objective overview in light of these concerns is difficult. In this presentation, however, we have tried to delineate the primary factors that influence LNG safety in a straightforward manner, considering what is perceived to be a reasonable consensus within the engineering and scientific community. The overall presentation covers the primary types of LNG facilities and operations, the properties and intrinsic hazards of LNG, its containment, the measurement of safety, and a brief listing of some of the safety issues and problems that remain.

LNG facilities and operations

There are two basic types of LNG facilities; peak-shaving plants and baseload or import terminals. Figure 14 shows a peak-shaving

plant. In this type of facility, natural gas taken from the transmission line that carries the gas from the gas wells to distribution centers is liquefied during periods of the year when the demand is low, stored in large holding tanks as a liquid, and then—when demand rises in the winter—liquid is withdrawn, heated to a gaseous state, and used to supplement the gas being received from the transmission line itself. There are well over 50 of these facilities in existence in the United States, located in or near major cities. Some of them have been operating continually for up to 13 years.

FIGURE 14. Peak shaving plant.

Figure 15 shows an LNG import terminal. This plant does not have the capability to liquefy natural gas. Instead it receives the liquid by tanker from an overseas supplier, for example, one located in Algeria. The liquid is stored in the large holding tanks and is withdrawn, regasified, and then sent out to the local distribution system as the demand arises. Liquid is also shipped from this terminal by highway trucks to peak-shaving plants and satellite storage facilities that service smaller, more remote distribution systems.

This particular installation, located in Everett, Mass., is the only one in the United States that is currently operational. There are, however, other larger facilities that have been built and are essentially ready to receive tanker deliveries. These installations are located in Cove Point, Md.; Savannah, Ga.; and Staten Island, N.Y. In addition, new import terminals are being planned for the gulf coast and California.

LNG properties and characteristics

The primary ingredient of natural gas is methane; its other ingredients include ethane, propane, and a little nitrogen. The primary ingre-

FIGURE 15. Distrigas LNG Import Terminal.

dients of liquefied petroleum gases (LPG), on the other hand, are propane or propane and butane. The important physical properties of these gases are shown in figure 16. Methane has the lowest boiling point (minus 162° C or minus 259° F) of the hydrocarbons listed. Being a cryogen it is kept as a liquid by storing it at or near its boiling point and at slightly higher than atmospheric pressure. The liquid requires about one six-hundredth (.001666) the space required for an equivalent weight of gas. Liquid propane (LPG), on the other hand, is sometimes stored at or near its boiling point, usually when large quantities are involved or pressurized at ambient temperature, as for highway and rail transportation. Methane gas is flammable when mixed with air in concentrations of 5 to 15 percent by volume. Its heat of combustion is a little higher than the other energy gases.

COMPARISON OF SOME PHYSICAL PROPERTIES

	METHANE	ETHANE	PROPANE	BUTANE
MOL WT	16	30	44	58
BP °C	-162	-89	-42	-12
SP GR LIQUID	0.30	0.38	0.51	0.56
SP GR VAPOR - SATD	1.40	1.47	1.84	2.00
- 5 °C	0.55	1.04	1.52	2.07
LFL %	5	2.9	2.1	1.8
UFL %	15	13	9.5	8.4
HEAT OF COMBUSTION KCAL/KG	13,271	12,403	12,037	11,800

FIGURE 16. Physical properties of energy gases.

LNG hazards

If LNG accidentally escapes from its container, it represents a hazard to both people and property. Being very cold (−260° F) it will freeze skin tissue on contact. Although it is not toxic, it can cause asphyxiation when it evaporates, since its vapors will displace oxygen in the air. The methane content of the air has to exceed about 52 percent by volume, however, before asphyxiation will occur. Since this percentage greatly exceeds that required for the mixture to become flammable, the fire hazard is generally of greater concern.

LNG may also explode—another form of hazard. If LNG vapor is mixed with air and ignited within some type of confinement, such as a building, the resulting rapid release of energy will cause the pressure of the LNG to rise to the point where the confining medium bursts or "explodes." Considerable research has been done on the possibility of unconfined mixtures—as might occur in a large LNG spill—exploding when ignited. However, no evidence that this kind of explosion or detonation, will occur has ever been found, and thus there is a general consensus that this is not a credible hazard.

Another type of explosion occurs when LNG is accidentally spilled on water. It is an unusual phenomenon involving vaporization at an extremely high rate followed by an air blast—and this occurs without the fuel combusting. Research studies have demonstrated, however, that this phenomenon occurs only when the content of the higher hydrocarbons, such as ethane, is greater than that present in most all LNG that is shipped or stored. However, even when such explosions do occur, their energy content is relatively small.

The primary hazard resulting from the escape of LNG is fire. If accidentally spilled on the ground, the LNG evaporates very rapidly; and if the resulting vapor is ignited right away, a fire will develop over the evaporating pool of liquid—and it will continue to burn until all of the liquid has evaporated. If the spill is large, the fire may be of substantial dimensions, and the resulting thermal radiation can cause injury and damage at some distance away from the fire.

If the vapor is not ignited, it will form a cloud that will move downwind. This cloud will remain just above ground level because the vapor at the boiling point of the liquid is more dense than the surrounding air. However, the natural turbulence of the air will dilute the vapor cloud as it travels downwind—eventually becoming so diluted that it is no longer flammable. If the cloud is ignited at some point downwind before it becomes fully diluted, it will burn and cause thermal injury and damage to anything it envelops.

Figure 17 shows an LNG pool fire. In this scenario the LNG has been spilled on water and the resulting vapor has ignited. As the liquid spreads on the water, the mass rate of evaporation increases and the fire becomes larger, as shown in figure 18.

Experiments of this kind, combined with analytical techniques that account for the physical processes that take place, have made possible predicting the size of LNG pool fires and the thermal radiation emanating from the flame. For example, the size of a burning pool and its total burning time as a function of several pool sizes are presented in figure 19. These values derive from very rapid spills onto water as might occur if a shipborne container suffered major damage and an

FIGURE 17. LNG pool fire.

FIGURE 18. LNG pool fire.

LNG spill occurred. A single container of a large (125,000 m^3) LNG tanker would hold about 25,000 m^3 of LNG weighing about 10,000 tons.

The effects of thermal radiation external to LNG fires are presented in figure 20. The figure shows that, for the largest spill, the fire can cause second-degree burns at distances up to 8,200 feet from the center of the burning pool. Clothing, buildings, and other structures

Maximum Pool Radius and Duration
for Various LNG Spill Volumes
(from reference 5)

(fuel regression rate = one inch/min)

LNG Spill Tons	Maximum Pool Radius Feet	Maximum Pool Burning Time Seconds
50	165 *	65 *
100	210	75
1,000	500	135
10,000	1195	245

*figures rounded off

FIGURE 19. Size of a burning pool and its total burning time as a function of several pool sizes.

that block radiation will, of course, afford considerable protection. A fire from the largest spill could ignite wood at distances of up to 1,750 feet.

The development of a flammable methane vapor cloud is shown in figure 21. The LNG has spilled on the ground within a diked area, and a vapor cloud has formed very rapidly. The visible cloud is actually condensed water vapor rather than methane since the methane gas is not visible; however, the visible cloud generally represents the extent of the methane that can be ignited. After a very short interval of time, the prevailing wind interacts with the cloud, and it travels with the wind, as shown in figure 22.

Limiting Distances for Thermal Effects
from LNG Pool Fires
(from reference 5)

	Spill Amounts (Tons)			
	50	100	1000	10,000*
Second degree burns 2 + burn	800 ft	1050 ft	2950 ft	8200 ft
Ignition of wood (piloted ignition)	240 ft	330 ft	760 ft	1750 ft

*values not given in reference 5 but calculated by the same method

FIGURE 20. Limiting distances for thermal effects from LNG pool fires.

Again, as in the case of pool fires, experimentation and analysis have provided a means of predicting the downwind dispersion of vapor clouds as a function of (a) spill rate and quantity, (b) the sur-

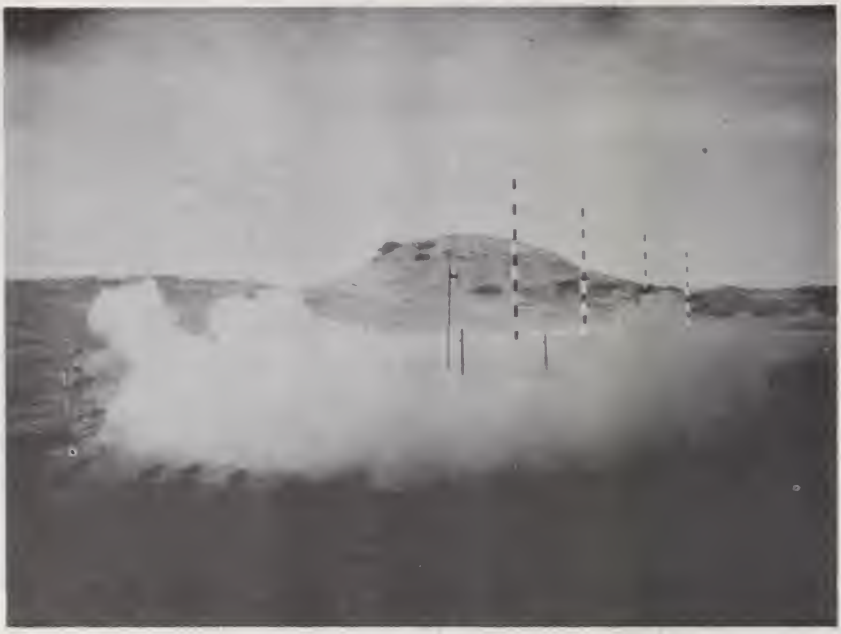


FIGURE 21. Flammable methane vapor cloud.

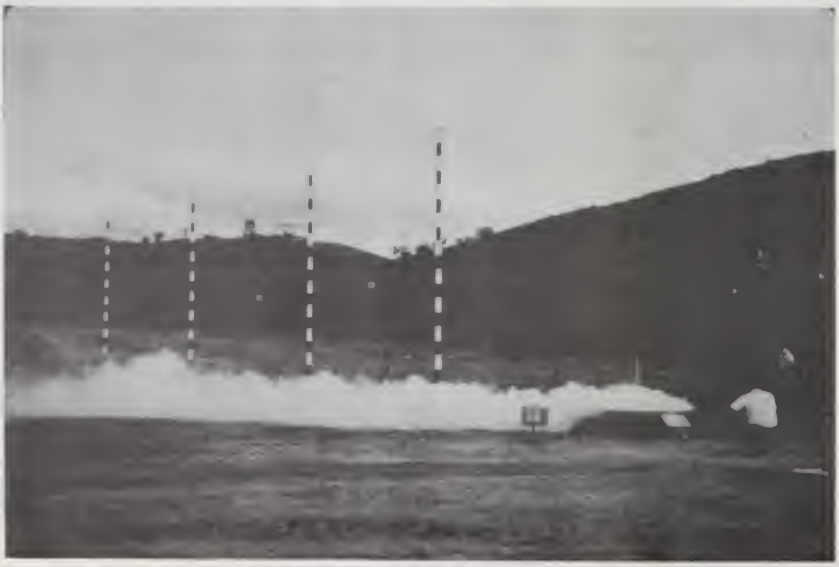


FIGURE 22. Wind interaction with flammable methane vapor cloud.

face upon which it is spilled, and (c) the prevailing meteorological conditions. The results of one set of predictions are given in figure 23 for accidental spills on water. The figure shows that for the largest quantity, 10,000 tons (~25,000 m^3), under the weather conditions unfavorable to diluting the cloud, it might travel for about 12 miles before becoming completely dispersed and no longer flammable. The maximum diameter of the cloud might be as much as a mile, but it would shrink considerably, long before it traveled its maximum distance. The maximum condition, of course, would result only if the cloud were not ignited. If the cloud entered a populated area, it would undoubtedly be ignited very quickly by one or more of many potential ignition sources present, and its forward progress would then be stopped. It may also be of interest to note in this figure that spills of refrigerated LPG are capable of producing almost the same results.

SPILLS ON WATER

(Under Worst Weather Conditions)

	LNG		LPG	
Spill Quantity (Tons)	Max. Half-Width (Ft.)	Max. Extent (Miles)	Max. Half-Width (Ft.)	Max. Extent (Ft.)
100	340	1.5	320	1.4
1,000	860	4.5	800	3.9
10,000	2,020	12	2000	11

FIGURE 23. Prediction data on downwind dispersion of LNG and LPG vapor clouds.

LNG containment

LNG presents a hazard only if it is accidentally released from its container. Regulations and careful installation of LNG systems mitigate against the occurrence of major containment failures. Terminal storage tanks are double-walled with the inner container's structural material able to withstand cryogenic temperatures. Impacts from earthquakes, winds, tornadoes, and the like, are taken into account in their design and careful inspection (e.g., X-raying of all welds) and testing further reduces the likelihood of a failure.

In addition, storage tanks are surrounded by dikes or impounding basins to confine an accidental spill. Dikes or basins limit the area over which heat may be transferred from the ground to the liquid pool, and serve to restrict the size of the pool fire or the extent of the vapor cloud that might occur. Current regulations specify that the distance beween the edge of a dike and the plant property line must be such that the thermal radiation beyond the plant boundary will not exceed a specific value, 10,000 Btu/hr./$ft.^2$—under certain prescribed conditions. At present, Federal regulations do not stipulate distances from the dike to the plant boundary that would make it impossible for a flammable cloud to reach beyond the plant's boundary.

The containment of LNG tankers consists of a basic cryogenic-compatible internal container surrounded by insulation. Tankers also have double hulls which greatly reduce the vulnerability of these containers to damage by collision, impact, or grounding. Oil tankers, on the other hand, only have a single hull that is in contact with water on its external surface and with oil on its interior surface.

A sketch of the cross-section (plan view) of one type of LNG tanker is shown in figure 24. This tanker has five freestanding spherical tanks; portions of three of these spheres are shown in the figure. The double hull, the supporting structure, and decks provide considerable resistance to external impacts.

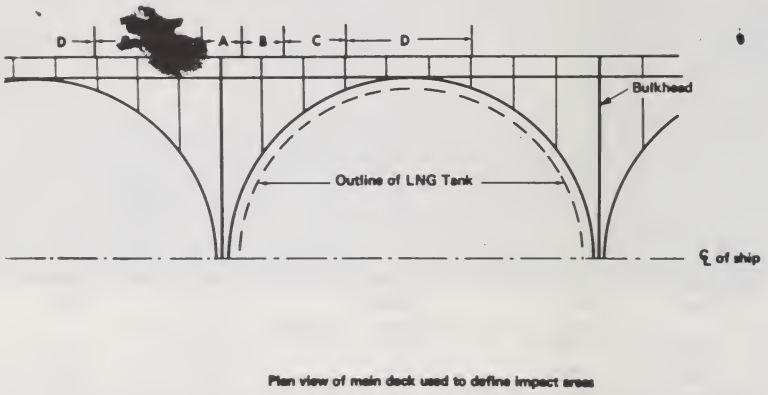


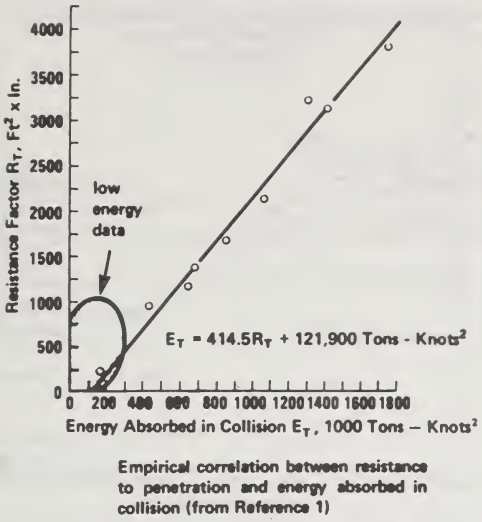
FIGURE 24. Cross-section of one type of LNG tanker.

Measurement of safety

From the preceding discussion, it is apparent that an accidental spill of LNG could produce a thermal hazard to the surroundings. The likelihood of this occurring, however, is very small. However, one method of taking these two factors—the probability of occurrence and the hazards—into account in asessing the safety of LNG operations is that of estimating risks. These risks can be estimated by multiplying the probability of an event occurring by the consequences of an event; this would yield, for example, an estimate of the annual probability of a certain level of injury or damage occurring.

Risk estimates have been made for terminals and for LNG tanker operations. In concept, all potential events that might singly, or in combination, lead to an accidental spill are identified, their probabilities of occurrence derived from past experience with similar systems, the combinations of events organized (in the form of fault trees), and the total probability of the major event occurring estimated from the probabilities of the contributing events. The consequences of the spill are estimated from predictions of injury and damage caused by pool fires and the burning of vapor clouds.

A brief example of this form of analysis is that carried out for an LNG tanker operation. The problem is to estimate the risk of an LNG spill caused by another ship colliding with the LNG tanker. The steps in the analysis follow:



Empirical correlation between resistance to penetration and energy absorbed in collision (from Reference 1)

FIGURE 25. Correlation analysis.

Step 1.—The structural resistance of the LNG tanker to the impact of another ship is estimated. This is done by utilizing a correlation of the kind shown in figure 25 where actual damage observed in a number of ship collisions is used to relate energy absorbed by the metal structure of the ship to the resistance of impact. This provides a basis for determining the extent of damage as it relates to the amount of resisting material on the impacted ship and the speed and displacement of the impacting ship. The relationship between impact speed and displacement necessary for sufficient penetration to cause an LNG spill is given in figure 26. Areas A, B, C, and D represent positions along the side of the ship where requirements necessary for damage to the inner LNG containers are different. It can be seen that, except for the most vulnerable points (area D), the impacting ship must be traveling at a fair rate of speed and impact the LNG tanker beam-on (at right angles) before damages great enough to cause a spill would occur. This correlation is then further expanded to take into account different angles of impact.

Step 2.—The probability that another ship impacting the LNG tanker under the conditions determined in Step 1 would next be estimated. This estimate takes into account the range of ship sizes that the LNG tanker may meet on its way into port, their speed, the frequency of accidents that have occurred in the past, and the possible angles of impact. The probability of this occurring for a typical operation is of the order of 1 in 100,000 to 1 in 10,000 per year of operation.

Step 3.—The consequences of the accident, given a spill, are estimated, using predictions that were shown in Figures 20 and 23.

Step 4.—As one measure of risk, the probability of an individual located on shore suffering a fatality as the result of an LNG tanker collision is derived from the probability of a spill occurring and the

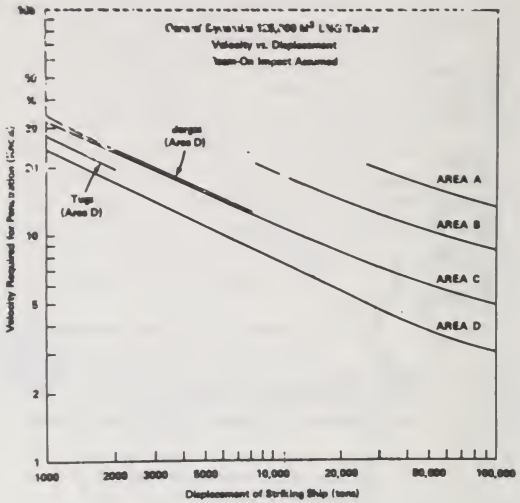


FIGURE 26. Relationship between impact speed and displacement necessary for sufficient penetration to cause an LNG spill.

potential consequences of the spill. This value for a typical case is something of the order of 1 chance in 1 million per year (1×10^{-10} per hour).

Once estimates of a risk are made, their significance may be determined by comparing this risk with that of others to which the average

RISKS FROM VOLUNTARY ACTIVITIES

Activity	Fatalities/person-hour* of exposure
Motor Vehicles	1×10^{-6} (one in a million)
Commercial Aviation	1×10^{-6}
Smoking	5×10^{-7} (five chances in 10 million)
Railroad Travel	$\approx 5 \times 10^{-8}$ (five chances in 100 million
Skiing	1×10^{-6}
Hunting	1×10^{-6}

FIGURE 27. Risks from voluntary activities.

RISKS FROM INVOLUNTARY ACTIVITIES OR CAUSES

Cause	Fatalities/person-hour of exposure*
Fire (while at home)	5×10^{-9} (5 chances in a billion)
Accident (at home)	2×10^{-8} (2 chances in 100 million)
Electricity (home wiring and appliances)	1×10^{-10} (1 chance in 10 billion)
Struck accidentally by falling object	8×10^{-10}
Inhalation and Ingestion of food	1×10^{-9}
Explosion of Pressure Vessel	3×10^{-11} (3 chances in 100 billion)

FIGURE 28. Risks from voluntary activities or causes.

person is normally exposed, as shown in figures 27 and 28. These figures show that individual risks on the average, for voluntary activities are of the order of 1 in 1 million per hour and for involuntary activities of around 1 in 10 billion per hour. For the LNG example given here, the risk to an individual from an LNG tanker accident tends to be less than that from most other risks that are, in effect, accepted during one's everyday life. Actually, Coast Guard control of shipping and better-than-normal operational rules for shipping tend to reduce risks of LNG shipping accidents to even lower values.

This kind of analysis is helpful in that it more clearly reveals the various factors that contribute to risk (so that important areas where effective measures for reducing risks may be identified), and it also provides a quantitative way of measuring safety.

Remaining issues

The issues most commonly mentioned in considering the safety of LNG imports are presented in figure 29. To this list one might add:

Is there a need to control the selection of sites for LNG importation?

Are further measures for improving safety feasible and practical?

Summary

The hazards of LNG have been identified, sufficient research has been conducted so that the hazards are reasonably understood, detailed and comprehensive analyses of failures have been conducted, and measures of risk have been derived. Remaining issues that are currently receiving additional attention have been identified and are being evaluated by both industry and the Government.

MODERATOR. Thank you, Don, for that excellent presentation on LNG safety concerns.

IS THERE A NEED FOR THE FUEL?

DO PRESENT REGULATIONS ADEQUATELY SAFEGUARD PUBLIC SAFETY?

CAN NEW FACILITIES BE BUILT WITHOUT UNDUE DELAYS?

IS MORE RESEARCH NEEDED TO AID FACILITY DESIGNERS AND/OR REGULATORY GROUPS?

PREVENTION AND CONTROL TECHNOLOGY

FIRE AND DETONATION HAZARDS

FLAMMABLE VAPOR DISPERSION

FIGURE 29. Issues associated with the safety of LNG imports.

PART III. INDUSTRY PERSPECTIVES, COMMENTS BY PUBLIC INTEREST GROUPS, AND GENERAL DISCUSSION

MODERATOR. The last part of the seminar will be an opportunity for some oral interchange between industry, Federal and State officials, congressional staff, and public interest groups.

Just to orient you to some of the people who are present today, it should be noted that we have representatives from the Coast Guard, FERC, ERA, Department of Energy, and Department of Transportation. From the industry side, we have representatives from Cabot Corp., Public Service Electric & Gas Co., El Paso.; Trunkline, and several LNG consultants. We also have representatives from the Environmental Policy Center, representatives from a Nader interest group, and two representatives from BLAST.

What we'll try to do during this part of the seminar is to obtain a diversity of perspectives and opinions. Please feel free to talk on any issue. Mr. Abbotts, did you want to go first?

A. Public interest research group

JOHN ABBOTTS. I'm John Abbotts, I'm with a public interest research group. I'd prefer to go last, but I'll go ahead and go first, and try and keep it brief. There's really one issue that I specifically want to talk about, and that's the liability issue. I'd just like to put in a pitch to the congressional representatives here that if the liability issue becomes one that's considered legislatively, that they not make the mistake that was made 20 years ago with the nuclear industry, in passing Price-Anderson.

Now, if they give the LNG or LEG—liquified energy gas—industry an opportunity which Congress has never given the nuclear industry, and that's the opportunity to put its corporate assets where its mouth is. Specifically, the liability should be strict, liability should be unlimited, and the Federal Government should not get involved in the business of indemnification, or insurance, except perhaps to collect fees to establish a pool.

Just briefly, I think the other salutary effect that unlimited liability would have, is that with unlimited liability, the siting problems,

to some extent, would take care of themselves. In other words, with unlimited liability, companies would be encouraged not to site facilities in areas of seismic risk, and would be encouraged to site them away from populated areas.

MODERATOR. Mr. Cabot, did you want to respond to that, or offer any other comments?

B. Distrigas Corp.

JOHN CABOT. Well, not specifically to that. I'm not aware that there's any limitation on liability today, but my main point is that, I would like to express a little disappointment that the GAO is not present today. I'd rather hoped that we'd have a chance to learn more about a report. I've, in the past, been very impressed by the work that the GAO has done, and I guess I feel a little peculiar about this latest one, because the only place I could read much about it is in the New York Times. It seems to me it would be very useful to have a report that could be acted upon by the industry, or by regulatory authorities, or by the Congress itself, to be available to the industry, to the regulatory authorities, and possibly to the Congress. And I'm sorry we haven't had a chance to have it released already.

MODERATOR. Any other comments?

PETER HUNT. I have one question, I guess, at this point—during the hearings, we'll be able to do a lot more—but, to Peter Johnson. Indeed, when there is the closing, basically, of the channel in the Port of Boston, from the standpoint of providing a single clear lane for the *Descartes* when she comes in—are the other people who would like to use that port at the same time compensated for this interruption? Since indeed, the *Descartes* takes really about the best weather and the best time of day for its transit.

PETER JOHNSON. No; it's my understanding that there's no compensation to the other traffic in the area, and I guess one of the thoughts that we had when we were looking into this was the fact that Boston Harbor is not a very busy harbor compared to some others——

HUNT. Well, New York is——

JOHNSON. New York is a very busy harbor, the Chesapeake Bay is a very busy harbor, but to my knowledge there's no——

MODERATOR. Someone else wants to address that question. Person asks for identity of Hunt.

HUNT. I'm sorry, Peter Hunt, Director of Research and Analysis for the Subcommittee on Energy and Power, of the House Interstate and Foreign Commerce Committee.

MODERATOR. I have a question for Mr. Allan, if he doesn't mind addressing us again. Does Arthur D. Little have any stated position on whether, if there was a severe rupture of an LNG tank, what good would the dikes do, and under what conditions would it contain a spill?

ALLAN. The dikes surrounding the LNG tanks, both the peak-shaving facilities and the baseload terminals are designed so that large flows of LNG from the tanks, in the event some kind of an accident occurred, and the LNG was released, that the dikes would contain the liquid. And, as I said before, they are designed so that the . . . have been analyzed for the extent of the fire that would be produced, that could ignite it right away, and the extent of the flammable vapor

cloud. Other factors that go into the design, are those that have to do with the structural characteristics of the dike so that they'll be ensured that they'll withstand the dynamic head of the flow of the LNG when it reaches the edge of the dike. There's been concern about overflow over the dike, and that has been addressed in most designs.

There's a concern about, if you have two tanks, and one dike, of the LNG liquid, if it's spilled from one tank, contacting the outer wall of the other tank that still has maintained its integrity, and it, being normal steel, becoming brittle. The current regulation requires that the facility be designed so that won't happen.

MODERATOR. Our next speaker is Gene Coscriff of BLAST.

C. Statement of BLAST (Bring Legal Action to Stop Tanks)

GENE COSCRIFF. I am here to present the position of BLAST—Bring Legal Action to Stop Tanks—on the importation of LNG into the United States. We are totally opposed to the storage and transportation of LNG in any populated area. We wish to stress the fact, that this is not merely a local or provincial position. Admittedly, BLAST started as a local umbrella group of concerned Staten Island individuals and organizations, formed to present a united front, in opposition to the siting of two 900,000-barrel capacity LNG storage tanks in Rossville, Staten Island. We were not formed in reaction to the TETCO LNG explosion of February 10, 1973, since we had started our active opposition to LNG storage and transportation in 1972.

Originally, we officially represented 35,000 people on Staten Island, whose signatures are on record with the FPC. But a public poll taken by New York State Senator John Marchi proved that we represent the viewpoint of nearly all Staten Island voters.

However, in the last 5 years, we have been joined in our position of opposition to LNG, by groups representing vast numbers of people in other areas. A chapter of BLAST has been formed in Greenpoint, Brooklyn. The Bay Ridge Community of Brooklyn representing 81 organizations, voted to support BLAST as did the Bay Ridge Human Resources Advisory Council representing over 460,000 people. Groups in Seawaren, West Deptford and Logan Township, New Jersey have publicly announced their support. And groups in Providence, R.I., Eugene, Oreg., and San Pedro, Calif., have also joined the LNG battle.

Outside of the United States we have been joined in our position by groups in New Brunswick, Canada; Canvey Island, England; and Aberdour, Fife, Scotland with whom we maintain an exchange of information. All of these hundreds of thousands of people, in widespread areas, are totally opposed to the storage and transportation of LNG in or near populated areas. This opposition is based on concern for the lives and property that would be endangered by a major LNG mishap.

Since a large spill of LNG will produce a rapidly expanding, super cold, ground or water hugging cloud or "plume," that can travel considerable distances, under certain meteorological conditions, before carbonizing and reaching a source of ignition; the danger is not only to the immediate spill area, but is potentially widespread.

An LNG "plume" will freeze biological life, or cause suffocation by displacing oxygen, and then incinerate people and property, in and

near its confines, when it is ignited. There is no known control of a major LNG spill or fire. The New York City Fire Department, whose expertise in fighting and controlling the almost countless fires that occur in the teeming New York metropolis is renowned, admits it would be reduced to "search and rescue" tactics, in the event of a major LNG mishap. Recent LNG cloud experiments, done for the U.S. Coast Guard, by the U.S. Naval Weapons Center at China Lake, Calif., have proven that the behavior of LNG clouds is erratic and unpredictable; and therefore extrapolations from former small scale experiments are meaningless. These facts alone merit the banning of LNG from populated areas. The gas industry repeatedly claims that preventative measures will guarantee against major LNG mishaps. But, no matter what boasts the industry makes about elaborate construction of LNG tanks and tankers, and redundant safety devices, there is no way to eliminate the possibility of human error, mechanical failure and the ever increasing threat of terrorism and sabotage. There is nothing made by man, that cannot fail or be made to fail. As Murphy's law of perversity states, "If any thing can go wrong, it will and at the worst possible time."

Moreover, although the prime concern of BLAST has been, and will continue to be LNG safety and proper siting of LNG facilities, as consumers and American citizens, we are also opposed to the importation of LNG to the United States, at the present time, for additional reasons.

The first of which, is that the price of imported LNG will be three to five times that of domestic pipeline gas. Since this high cost will make it unattractive to potential LNG customers, as well as perspective LNG investors, the LNG industry is vigorously opposing "incremental pricing" of LNG by which LNG purchasers would pay the full cost. Instead, they are pushing for "rolled-in" pricing, by which the cost of imported LNG would be included with that of domestic gas. Thus, all gas consumers, whether or not they use LNG, would subsidize imported LNG. Why should another financial burden be placed upon the American consumer already struggling with the high cost of living?

The second reason for our opposition to the importation of LNG is the question of "reliability of source." LNG projects involve contracts of 20-year duration. How can we seriously consider becoming reliant on Algeria as our source of LNG supply, for a 20-year period? Last October, legislation introduced by nine U.S. Senators, led by Senator Jacob Javits, Republican, of New York and Senator Abraham A. Ribicoff, Democrat, of Connecticus—S. 2236—called for the imposition of stiff sanctions on countries that aid or abet terrorists. And the list of more than a dozen countries, accumulated by the Ribicoff committee staff, that might be considered to be supporting terrorist activities by supplying arms and money, giving asylum, and allowing terrorists to train on their territory and the like, includes Algeria. Surely, entering into 20-year contracts for purchasing enormous quantities of LNG would make a mockery of the so-called "stiff sanctions" of S. 2236 and indirectly be supportive of the terrorist elements that threaten the United States as well as other nations of the world.

And finally, BLAST believes that the importation of LNG from Algeria, will have serious adverse ramifications on any hopes our Nation may have for achieving energy independence. Algeria participated in the Arab oil embargo and is now involved in the formation of a natural gas cartel, which eventually would be in a position to "put the squeeze" on the U.S. gas supplies, if we become dependent on Algeria as a supplier.

The U.S. is not running out of natural gas. Our proven gas reserves are second only to those of Russia, whose reserves are the world's largest. The present glut of intrastate natural gas and just the untapped Alaskan reserves which would be available with the necessary investment of capital, prove that energy independence is an achievable goal. The diversion of huge amounts of capital to LNG import projects for 20-year periods will not only hinder the development of proven gas reserves as well as unproven gas reserves, but will seriously impede the development of alternate energy sources, including coal gasification and solar energy. In addition the adverse effect on our balance of payments goes without saying.

In conclusion, we urge that the importation of LNG from Algeria into the United States be rejected for safety considerations, lack of national siting criteria, questions of sound economics, and national security, and in the interest of achieving American energy independence.

MODERATOR: Mr. Hunsacker, or Mr. Norman, would you care to offer any comments or responses?

HUNSACKER. I wouldn't care to dignify it, thank you.

D. Dick Norman—LNG consultant, employed by J. Makowski Associates, Inc.

DICK NORMAN. My name is Dick Norman, I'm with a small Boston consulting firm, and formerly was employed by Distrigas Corp., and also headed up the Maritime Administration's LNG shipping program for a couple of years in 1973 and 1974. More recently, I have been doing some consulting with regard both to LNG project development, and LNG siting and safety.

My purpose today is not to act as an advocate for many of the positions that have been taken, nor to try and refute some of the other statements which have been made, but more to try and summarize the dilemma which I think the Congress, the industry, and other people have with regard to LNG.

I think one of the most difficult, or one of the most pressing problems, with respect to a discussion of LNG is the recognition of the extensive work which has been accomplished both by the Government and by the industry, in an attempt to put to bed problems which people have raised this morning. I think all too frequently, people who are new to the industry do not take the time, or are not aware of much of the work that's been done before, which has tried to come to grips with the problems that appear to confront the Congress at the present time. I think if there were some way to rationally address the problems, there probably would be some easy and ready answers.

I'm not going to go point by point and try to refute some of the statements—some I disagree with, some I agree with. But I'd like to

point out as an example, the question of incremental pricing, which has been addressed by several speakers, and merely call to your attention more than 2 years of testimony which was presented before the Federal Power Commission, both from a philosophical, from a social, and from a practical point of view.

I don't think anyone is convinced what the right answer is as yet, but there's an extensive amount of work that has been done, there were decisions that were reached by the FPC, which are being reviewed again. Second, a specific example with regard to the problems about incremental pricing: There are probably no less than six definitions which are being used by various advocates and opponents of incremental pricing.

I'd advise you, if you get into that area, to make sure exactly what people are talking about. Similarly there's the distinction to be drawn between the transmission and distribution companies. The transmission companies are faced with a very practical financing problem, some of the distribution companies, on the other hand, such as Southern California Gas Co., can readily accept incremental pricing, because they are regulated by State officials, who set their own rate-making policies.

There is no simple answer, it's a very complicated situation. And I hope that whatever action is taken will make sure that the opposing sides are heard, before a decision is reached. Second, with regard to energy supply. I confess to the fact that I view LNG imports in a very simple manner—either we're going to import more oil, or we're going to import LNG.

There are advantages and disadvantages to it, such as balance of payment, such as the employment benefit, which would be felt throughout the country, in various regions—shipbuilding, aluminum, steel, and other areas. Again, those are points of view, but again, I think people should be aware of the issues, and I think that they should take them into consideration, if and when, legislation is proposed.

I think it's unfortunate that articles such as the New York Times article of last week, and other things, tend to put emotion into some very legitimate concerns which have been raised by people. I think OTA should be commended for a real effort to prepare an objective analysis. Again, I disagree with some points, I agree with others. But I think the problem that the Congress faces, the problem that the staff members face, are to make sure that legitimate issues are not masked, and to take the time to try and hear both sides of the picture before any decisions are reached. Thank you.

PETER HUNT. I have a simple question for Mr. Norman. What work has gone on within the last year on the issues of dynamic mixing, the Sterling Colgate and Teller problem that was raised in California about a year ago?

NORMAN. I can't respond definitively to it. I know that the AGA has made some attempts to look into it. I believe Chicago Bridge & Iron has. I think that some of the other companies are directly involved. I am not an engineer or a scientist—I know that when the question was raised by various people, they went and looked into the issue, but I can't give you a definitive answer on what it is.

HUNT. Is there another panel member who can address it?

HUNSACKER. I wonder if the Coast Guard representative might have the answer to that?

MODERATOR. Dr. Schneider?

Dr. SCHNEIDER. We've not done any work in that area, and I'm not aware of Government agencies doing work in that area.

HUNT. Does the Coast Guard consider it a legitimate concern?

Dr. SCHNEIDER. We're presently reevaluating our future R. & D. plans, and we're going to be considering that and every other problem, real or otherwise, to determine where we should be concentrating our efforts. I can't answer you now. We haven't made the final decision on where we're going to go, in any area of LNG research, at this particular moment.

ELINOR SCHWARTZ. I'm Elinor Schwartz with the California State office, and I'm interested in what some of the various possible definitions of remote siting might be, and what appropriate population densities seem to be according to some of the different viewpoints.

PETER JOHNSON. I don't think that we came to any answer on that question at all, but, what we considered in the whole look at it, was the safety issue involving the differences of opinion about travelling distances for vapor cloud dispersion, and the problems of assumptions that one puts into those models, and that leads you to a very large variation in distances from an assumed accident site.

Seemed to us, though, that there was more than just an assumed distance from a tank that should be considered in remote siting, and one should also consider the tanker traffic and the harbor situation and the terminal situation, as well as the land situation, and put that all together when you talk about remote siting.

E. Summary and wrap-up

MODERATOR. This seminar has indicated that there are many different perspectives on all of the policy concerns posed by the emerging LNG import industry. And we've only briefly looked at a few of these concerns. They deal with a range of questions, for example, those pertaining to research and development, incremental versus rolled-in pricing, siting, and safety issues.

I think the Congress is beginning to gear up again to increase its interest and oversight responsibilities over the LNG industry. The issuance of the GAO report, be it 6 weeks, or 2 months from today or whenever it comes out, will probably serve as a catalyst to increase congressional involvement.

I think all of the LNG policy issues are somewhat overlapping, and need to be interrelated with each other. These issues can't be examined only in the context of the LNG situation, but have to be looked at in broader terms of U.S. energy policy and U.S. environmental policy. Furthermore, I don't think that LNG can be looked at as an isolated entity, but it has to be related to an array of hazardous materials that have been introduced into society.

The problems and issues posed by the LNG industry are likely to require careful analysis by the Congress. We hope this seminar will contribute to this effort. On behalf of the Congressional Research Service, I thank you for your participation.

APPENDIX I

78-6-ENR

CONGRESS AND THE CONTROL OF HAZARDS OF MARINE TRANSPORTATION OF LIQUEFIED NATURAL GAS

WARREN H. DONNELLY
Senior Specialist, Energy
Environment and Natural Resources
Policy Division

and

DONNA S. KRAMER
Research Assistant
Environment and Natural Resources
Policy Division

January 10, 1977

CONGRESSIONAL RESEARCH SERVICE
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Summary

Beginning in the 1970s, there have been indications of limited but continuing congressional interest in the control of the hazards of marine transportation of liquefied natural gas (LNG). This interest peaked following the 1973 fire in an empty LNG storage tank in Staten Island, New York, and took an upturn again during the legislative effort that culminated in the Alaska Natural Gas Transportation Act of 1976. The partially completed legislative framework that now exists for control of LNG transportation hazards is largely the byproduct of legislation enacted for other reasons. This framework contains some ambiguities for the respective LNG safety responsibilities of the Federal Energy Regulatory Commission of the Department of Energy and the Department of Transportation. No major legislation dealing comprehensively with control of these hazards has been introduced or enacted.

Since 1969, most of the congressional interest has focused upon the jurisdictional aspects of regulating hazards of LNG marine transport. Little appears in the hearings from the literature of LNG safety about the nature of LNG accidents and the range of possible consequences, or on Federal research and development to improve technical understanding of LNG hazards and the means of preventing, limiting and otherwise dealing with LNG accidents. The issue of possible risks from tanker carriage of LNG from Alaska came up now and then during work on the Alaska Natural Gas Transportation Act and in subsequent consideration of the President's choice among three proposed systems, but did not appear to have been a controlling factor.

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The principal legislative issues relating to control of LNG hazards outstanding at the beginning of the second session of the 95th Congress in 1978 include:

(1) Clarification of the respective responsibilities of the Department of Transportation, the Coast Guard, the Federal Energy Regulatory Commission and the Department of Energy for safety in marine transportation of LNG, particularly for the situation of tankers at LNG terminals, and for siting of LNG terminals.

(2) Coordination of the respective regulatory approaches of these agencies.

(3) Coordination of their respective research and development programs.

(4) Clarification of responsibility for emergency planning in event of a substantial LNG accident.

Introduction

Now that Congress has four research and analytical arms -- the General Accounting Office, the Congressional Budget Office, the Office of Technology Assessment and the Congressional Research Service -- there is increasing interest in their cooperation and collaboration. In the fall of 1976, the General Accounting Office undertook a study of the hazards of the marine transportation of liquefied natural gas and invited the participation of the Congressional Research Service. The outcome was informal agreement for each agency to independently produce complementary reports.

For its part, the Congressional Research Service proceeded to examine congressional interest and actions in this matter, which are the subject of the following report.

The research and analysis for this CRS report was done by Dr. Warren H. Donnelly, Senior Specialist, Energy, and his Research Assistant, Ms. Donna S. Kramer, in consultation with John Jimison, a CRS Specialist for natural gas, and Paul Rothberg, a CRS Analyst working in transportation of hazardous materials. The analysis was circulated in draft to congressional committees with an interest in LNG matters and to industrial and public interest groups. The comments received are reflected in this final version.

The CRS report, since it focuses upon information reaching Congress through hearings and the Congressional Record, does not indicate the professional literature on hazards and safety aspects of liquefied natural gas. This we expect will be covered in the GAO's report. *

The statutory foundation for control of hazards of marine transportation of LNG

Well before control of the hazards of marine transportation of liquefied natural gas began to attract congressional attention, a legislative foundation for dealing with these hazards was being laid. This foundation now consists of nine statutes that indirectly deal with control of LNG hazards from ships

* A good review article on LNG is that of Elisabeth Drake and Robert C. Reid, "The importance of liquefied natural gas," which appeared in the Scientific American of April 1977.

and shore terminals. Of these statutes, two deal with natural gas, one with siting of facilities, four with marine transportation and two with protection of the environment. Taken together, these provide authority and opportunity for Federal action by the Federal Energy Regulatory Commission of the Department of Energy, the DOE itself, the Department of Transportation and the Coast Guard, the Council on Environmental Quality, the Environmental Protection Administration and the U.S. Army Corps of Engineers. However, none of the statutes provide for coordination of the exercise of these scattered authorities. A brief summary of these nine statutes appears in Table I.

Two Acts since 1972 bearing directly upon marine transportation of LNG are the Supplemental Appropriations Act for Fiscal Year 1973 and the Alaska Natural Gas Transportation Act of 1976. Summaries of these two Acts follow:

The Supplemental Appropriations Act for Fiscal Year 1973

By the early 1970s, even before the Arab oil embargo of 1973/1974, the Maritime Administration had begun to provide subsidy payments for construction of LNG carriers. In September 1972, the Administration signed the first subsidy contracts for construction of six liquefied natural gas carriers. 1/ The Administration next proposed to expand the subsidies

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1/ Contracts were signed on September 29, 1972, for three LNG carriers each of 125,000 cubic meters capacity to be constructed at the Quincy, Massachusetts, shipyard of the General Dynamic Corporation for the Ecogas project. Contracts signed on September 30, 1972, provided subsidy for three additional LNG carriers to be built by Newport News Shipbuilding for the El Paso Natural Gas Company. The subsidy contract awards for the six vessels totalled $141.9 million.

Table 1

LEGISLATIVE FRAMEWORK FOR CONTROL OF HAZARDS
OF LIQUEFIED NATURAL GAS BY THE FEDERAL GOVERNMENT

Subject	Statute	Effect: Direct	Effect: Indirect	Summary
Natural gas	Natural Gas Act of 1938		X	Authorizes FPC (DOE) to regulate imports, exports and interstate transportation of natural gas.
	Natural Gas Pipeline Safety Act of 1968 (P. L. 90-481)		X	Authorizes the Secretary of Transportation to set minimum Federal safety standards for pipelines.
	The Alaska Natural Gas Transportation Act of 1976 (P. L. 94-566)		X	Directed the Federal Power Commission in recommending to the President selection of a natural gas transportation system to include information on safety of the systems.
Facility construction and siting	Coastal Zone Management Act of 1972 (P. L. 92-583)		X	Provides for coastal States to develop management programs for land and water resources in their coastal zones. No Federal permit or license for an activity affecting a State's coastal zone can be issued unless the activity has been certified as consistent with the State's program.
	U. S. Code 33 U. S. C 403		X	The Army Corps of Engineers has jurisdiction over any structure in or on waters of the United States, as well as over any activity which would alter or modify ports, harbors, canals, navigable waters, and the like. No such structures or activities can be built or established without approval by the Secretary of the Army. This applies to fixed structures on the Outer Continental Shelf. It would also apply to structures for LNG terminals.
	The Marine Protection, Research and Sanctuaries Act of 1972 (P. L. 92-532)		X	Authorizes the Secretary of Commerce to designate areas of coastal waters of the Great Lakes as marine sanctuaries. Thereafter, no permit under other authorities for activities within a sanctuary is valid unless certified by the Secretary of Commerce to be consistent with the purposes of the Act. This extends to LNG facilities.
Transportation	Admiralty Extension Act of 1948		X	Provides that admiralty jurisdiction extends to all injuries caused by a vessel even if such damage or injury is "done or consummated" on land.
	Dangerous Cargo Act (P. L. 93-633; Title I,	X		Directs the Coast Guard to identify all dangerous cargoes, prescribe regulations establishing standards for containers and handling of explosives and other dangerous cargoes, and for inspection.
	Ports and Waterways Safety Act of 1972 (P. L. 92-340)	X		Authorizes the Secretary of Transportation to prescribe standards and regulations to promote the safety of vessels and structures in or adjacent to the navigable waters of the United States and to protect such waters and their resources from environmental harm due to vessel damage or loss. Authorizes the Secretary to prescribe minimum design, construction and operation standards for vessels carrying certain cargoes.
	Shipowners Limitation of Liability Act		X	Provides that shipowners may limit their liability after an accident involving their vessels to the value of the vessel and its cargo after the accident, except for loss of life or bodily injury, in which case liability is limited to $60 per ton of vessel.
Environmental protection	Federal Water Pollution Control Act Amendments of 1972 (P. L. 92-500)		X	Requires dischargers of pollutants to get permits from EPA and the Army Corps of Engineers. In some cases, the permit authority may be delegated to the States.
	National Environmental Policy Act of 1969		X	Requires that each major Federal action significantly affecting the quality of the human environment must be preceded by an analysis of the action's environmental impact.
Occupational Safety	The Occupational Safety and Health Act of 1970 (P. L. 91-596)		X	Authorizes the Department of Labor to set mandatory occupational health and safety standards for businesses in interstate commerce. Extends to LNG.
	Transportation of Explosives Act (18 U. S. C. 831)		X	Requires the Interstate Commerce Commission to regulate the safety of transportation within the United States of dangerous articles.
	The Department of Transportation Act of 1970 (P. L. 89-670)		X	Transfers regulation of transport of dangerous articles to the new Department of Transportation, including authority over transportation of LNG by land carrier, including rail, highway and pipeline, and by water; and also over packing, marking, loading, handling and delivery of LNG.

for LNG carriers and requested $175 million in the Fiscal Year 1973 supplemental appropriations for this purpose. In its justification, the Administration noted that LNG ships were a means of supplying clean, environmentally acceptable fuel to meet U.S. growing energy requirements. It mentioned no safety hazards associated with operation of such carriers.1/

The Supplemental Appropriation for Fiscal Year 1973 2/ included $175 million to the Maritime Administration for ship construction, contingent upon enactment of authorizing legislation bill S. 4036.3/ The funds were intended primarily for subsidy contracts for 11 more LNG carriers. No action was taken on S. 4036 and so the funds did not become available.

The Alaska Natural Gas Transportation Act of 1976

While the legislative effort that culminated in the Alaska Natural Gas Transportation Act of 1976 5/ had to do mainly with economic, environmental and international aspects of the several proposed routes for transportation of natural gas from Alaska to the continental United States, it included some attention to safety. Section 5 of the Act required the Federal Power Commission to recommend to the President the selection of such a transportation

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1/ Cf., U.S. Congress. Senate. Committee on Appropriations. Supplemental appropriations for fiscal year 1973. Hearings. 92d Cong., 2d sess., 1972, Part 2, pp. 1693-1713.

2/ P.L. 92-607, 86 Stat. 1498, approved October 31, 1972.

3/ S. 4036. Introduced by Senator Magnuson, upon request, September 26, 1972. The bill would have authorized an appropriation of $455 million for the Department of Commerce for FY 1973 for the acquisition, construction, or reconstruction of vessels and construction-differential subsidy, and the costs of national defense features for ships.

4/ P.L. 94-586, 90 Stat. 2903, approved October 22, 1976.

system and to provide a report which would discuss, among other things, the safety and efficiency in design and operation, and potential for interruption in deliveries of Alaska natural gas. Section 6 of the Act also authorized discretionary reports from other Federal agencies with respect to the FPC recommendation and report. Such reports were to include information concerning, among other things, the safety of the transportation systems. These reports are summarized later.

Legislative proposals affecting control of hazards of marine transportation of LNG

Some indications of possible extensions of the statutory foundation for government control of these LNG hazards can be found in legislative proposals during the 1970s. Thirteen bills dealing with one or another aspect of LNG transportation and safety were introduced during the period 1972-1977. Of these, six dealt with siting and construction of LNG facilities, three would have created a fleet of LNG tankers, one gave the Secretary of Transportation stronger controls over design, construction and operation of oil and LNG tankers, one addressed LNG safety hazards, and two focused upon economic aspects.

The bills were referred in the House to the Committees on Ways and Means or Interstate and Foreign Commerce, and in the Senate to the Committee on Interior and Insular Affairs (now the Committee on Energy and Natural Resources). A list and description of these bills appears in Table II and the range of their subject matter is indicated in Table III.

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Table II

LIST OF BILLS RELATING TO LIQUIFIED NATURAL GAS: 1972-1977

95th Congress, 1st session, 1977

H.R. 6844, introduced by Mr. Dingell May 3, 1977. A bill to regulate the siting, design, construction and operation of facilities for use in the transportation, storage and conversion of liquified natural gas. Referred to the Committee on Interstate and Foreign Commerce.

H. amendment No. 460, introduced by Mr. McClosky July 13, 1977. An amendment to H.R. 4963, the Maritime Appropriations Authorization Act, to prohibit construction subsidies for LNG carriers. Disapproved July 13, 1977.

H.R. 9731, introduced by Mr. St. Germain, October 25, 1977. A bill to provide that a liquefied natural gas facility may not be certified by FERC unless the Governor of the State and its legislature have approved the facility.

H.R. 9773, introduced by Mr. Beard of Rhode Island October 27, 1977. A bill to amend the Natural Gas Act to provide that no certificate for the construction or extension of any liquefied natural gas facility may be granted unless the facility or extension is approved by the State or States in which it is to be located. Referred to the Committee on Interstate and Foreign Commerce.

S. 682, introduced by Senator Magnuson, et al., February 10, 1977. A bill to amend the Ports and Waterways Safety Act of 1972. (Increased the regulatory power of the Secretary of Transportation over design, construction and operation of oil and LNG tankers. Passed by the Senate May 27, 1977.)

S. 2273, introduced by Senator Pell November 1, 1977. A bill to confer on the Secretary of Energy jurisdiction over construction permits and operating licenses for liquefied natural gas facilities. Referred to the Committee on Energy and Natural Resources.

94th Congress, 1st session, 1975

H.R. 4440, introduced by Mr. Murphy March 6, 1975. A bill to amend the Port and Waterways Safety Act of 1972 to require the Secretary of the Department in which the Coast Guard is operating to certify certain sites suitable for the location of liquefied natural gas storage terminals, and to prohibit the Federal Power Commission from issuing a certificate of public convenience and necessity for such terminals without such certification. Referred to the Committee on Merchant Marine and Fisheries.

93d Congress, 1st session, 1973

H.R. 4430, introduced by Mr. Wolff February 20, 1973. A bill to suspend the importation of liquefied natural gas and the construction of new storage facilities for LNG until a thorough investigation is made of the hazards associated with the marine transportation, delivery and storage of such gas, and other actions are taken to prevent or minimize hazards. Referred to the Committee on Ways and Means.

H.R. 5755, introduced by Mr. Wolff and nine cosponsors March 15, 1973. Identical to H.R. 4430. Referred to the Committee on Ways and Means.

92d Congress, 2d session, 1972

H.R. 13832, introduced by Mr. Anderson March 15, 1972. A bill to authorize the Secretary of Commerce to contract with shipbuilders of the United States and the Commonwealth of Puerto Rico for the construction, outfitting, and equipping of not more than

40 liquefied natural gas ships to be delivered not later than January 1, 1980. Referred to the Committee on Merchant Marine and Fisheries.

H.R. 14379, introduced by Mr. Dulski April 17, 1972. Identical to H.R. 13832. Referred to the Committee on Merchant Marine and Fisheries.

H.R. 15098, introduced by Mr. Anderson May 22, 1972. Identical to H.R. 13832. Referred to the Committee on Merchant Marine and Fisheries.

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Table III

PRINCIPAL SUBJECTS OF PROPOSED LEGISLATION CONCERNING TRANSPORTATION OF LIQUEFIED NATURAL GAS: 1972-1977

Subject	92d Congress 1972	93d Congress 1973	94th Congress 1975	95th Congress 1977
Siting and facilities		H.R. 4430	H.R. 4440	H.R. 6844 H.R. 9731 H.R. 9973 S. 2273
LNG tankers	H.R. 13832 H.R. 14379 H.R. 15098			S. 682
LNG safety hazards		H.R. 4430		
Economic aspects		H.R. 4430		Amendment to H.R. 4963

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Reports to Congress relevant to LNG hazards

From 1975 through 1977, Congress received five notable reports dealing in part with LNG hazards. Two of the reports were associated with choice of the route for transportation of natural gas from Alaska, two were initiated by the Comptroller General, and one was prepared at the request of the Office of Technology Assessment. Highlights from these reports on the subject of LNG hazards follow:

The FPC report to the President

As required by Section 5 of the Alaska Natural Gas Transportation Act of 1976, the Federal Power Commission reported to the President on selection of a route for transportation of natural gas from Alaska to the continental United States. Among other things, it addressed the safety and efficiency in design and operation, for various delivery systems. The FPC made its report and recommendations to the President on May 1, 1977. 1/ None of the six basic conclusions reached by the Commission or 15 important items recommended by it for attention referred to LNG safety. In its summary, the FPC discounted LNG safety hazards, saying: 2/ "We do not believe that an LNG system is inherently less reliable or more dangerous than a high-pressure buried pipeline. Nevertheless, liquefaction and regasification facilities must be planned with the utmost care."

In its detailed discussion of LNG safety and siting, the FPC noted that the possibility always exists that a spill of LNG could create an enormous

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1/ U.S. Federal Power Commission. Recommendation to the President. Alaska Natural Gas Transportation Systems. May 1, 1977, various pagings.

2/ Ibid., p. I-35.

gas cloud with at least some potentiality for damage to human life through combustion or asphyxiation. 1/ The Commission minimized this risk. It cited a report that a theoretical maximum of 113,000 casualties was possible at the California town of Oxnard--the proposed site for an LNG terminal--but that its probability was one in 100 billion-billion years, which was many times the age of the universe. An accident that might kill people near an LNG terminal might occur once in every million years. 2/ The FPC noted that LNG has been handled on both land and sea in many places with no loss of life due to an LNG catastrophe during the last 30 years. Of the Cleveland accident, the FPC briefly said, "It is true that in 1944, 133 people were killed in an LNG accident caused by the collapse of a fairly flimsy tank, surrounded by an inadequate dike..." 2/ Summarizing its analysis of LNG safety, the FPC said: 2/

> In summary, we find some advantage in basic conceptual reliability of conventional buried pipelines over an LNG mode of transportation. While the LNG system runs a miniscule chance of a major catastrophe, its more basic difficulty is the series of steps necessary for complete transportation, any one of which could be a trouble spot...

The President's report to Congress

On September 23, 1977, the President transmitted to Congress his decision and report on an Alaskan Natural Gas Transportation System. Since his decision was for an overland route--the Northern Natural Gas Pipeline

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1/ Ibid., p. VII-14.

2/ Ibid., p. VII-15.

3/ U.S. The President. Alaska Natural Gas Transportation System. Message from the President. September 23, 1977, 271 pp. House Doc. No. 95-225.

in Ottawa--there was little reason for his report to discuss LNG hazards in detail. In comparing the safety of the three competing systems, the President's report said the safety record for LNG storage and transportation had been excellent during the past quarter century. Nevertheless, said the President's report, LNG facilities present marginally higher risks of a major accident than do overland pipelines. An LNG project requires a careful approach to facility siting. According to the President, while the United States may need to rely more on LNG in the future, its use should be chosen where there is no economically and environmentally feasible alternative. 1/

A few weeks later the Senate Committee on Energy and Natural Resources published selected materials concerning the decision. 2/ One item was a report on LNG safety by an interagency task group 3/ which concluded that each of the three competing systems, assuming proper design and construction, could operate safely and reliably. However, the task group also said it was incumbent on those Federal officers or agencies who are responsible for pipeline safety to do all that is necessary to ensure, before initial operation, that the selected gas transportation system is designed and constructed in a manner consistent with Federal safety standards. The task group spoke of the need for "specific technical innovations present in liquefied natural gas processing and storage in an active

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1/ Ibid., p. 181.

2/ U.S. Congress. Senate. Committee on Energy and Natural Resources. Decision and report to Congress on the Alaska natural gas transportation system. 95th Cong., 1st sess., October 1977, 198 p. (Committee print.)

3/ Ibid., pp. 121-125.

area." 1/ It alluded to LNG hazards in its discussion of the proposal for marine shipment of LNG to California by tanker. Of this it said decisions would have to be made about location of the LNG processing and storage facilities which would assure their safety in active seismic areas. The task group believed that such doubts did not preclude consideration of the combination pipeline-LNG tanker proposal, "but much work remains to be done at both the Federal and State levels to facilitate LNG plant site construction." 2/

Congressional approval of the Presidential decision on the Alaska pipeline came in Joint Resolution 621, which the President approved on November 8, 1977, as Public Law 95-158.

The GAO report on the role of imported LNG

In October 1975, the Comptroller General reported to the Congress on the natural gas shortage and the role of imported LNG. 3/ While the report concentrated on economic and resource aspects, it summarized LNG safety and environmental problems as follows: 4/

> Safety hazards arise from transporting, handling, and storing any liquid or gaseous fuel. LNG is no exception. Due to its extremely low temperature, it can cause cryogenic burns on human flesh. If spilled on metal it can make the metal brittle to the point of structural failure, causing damage to ships or other equipment. After vaporization, LNG is readily combustible.

1/ Ibid., p. 121.

2/ Ibid., p. 122.

3/ U.S. Comptroller General of the United States. Natural gas shortage: the role of imported liquefied natural gas. October 17, 1975, report no. ID-76-14.

No LNG ships have been lost through fire or collision since such ships began operating in 1959. Two major accidents, both of unknown causes, have occurred in LNG plants in the United States. The first, in 1944, killed 13 persons; the other, in 1973, killed 40.

The Coast Guard has made extensive tests on LNG hazards and promulgated safety regulations to increase the safety of LNG carriers and facilities.

Environmental hazards connected with LNG are considered minimal. In its low temperature, liquid state, it will damage objects upon which it is spilled. In the gaseous state, it burns with slight atmospheric pollution compared with other fossil fuels.

The OTA report on transportation of LNG

Additional analysis of LNG safety hazards for Congress is to be found in a recent report of the Office of Technology Assessment. The OTA, which is one of the four analytical arms of the Congress, on September 28, 1977, forwarded to the Senate National Ocean Policy Study its assessment of the transportation of LNG which had been requested by the Study.1/ The report provided a concise analysis of current LNG technology and possible trends in the use of LNG, and identified and discussed many major policy issues.

The OTA's report advised Congress that the most serious LNG incidents could result from an LNG tanker accident. While LNG tankers appear to be well designed and constructed, better control of vessel traffic in U.S. ports and waterways, improved inspection procedures and mandatory crew and inspector training are needed. As for onshore LNG facilities, improved inspection procedures are needed for public safety. However, the major issue of onshore LNG facilities is where they should be located.2/ Of this

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1/ U.S. Office of Technology Assessment. Transportation of liquefied natural gas. Washington, D.C.: U.S. Govt. Print. Off., 1977, 101 p.

2/ Ibid., p. vii.

OTA said, "...There are currently no Federal guidelines for choosing sites of LNG or any other energy facility. There is considerable public pressure for such guidelines, particularly criteria which would limit facilities to unpopulated areas." 1/

Concerning safety, the OTA made no estimates of the effects of major LNG accidents. Instead it noted that past research had produced conflicting results and predictions for such accidents and it was unlikely future research would resolve the differences and come to firm decisions. So public policy decisions about LNG systems probably would be made on the basis of non-quantitative approaches. 1/

The report identified nine areas which might be of interest to Congress for legislation, oversight or appropriations. 2/ One concerned safety: In regard to LNG safety research, the OTA observed that use of disaster scenarios to search for possible faults in a system is a useful analytical approach, "but to infer, as most LNG safety reports do, however inadvertently, that all the important possibilities have been 'covered,' may be shortsighted." 3/ Past LNG research has been inconclusive because researchers used different initial assumptions about a spill, had different concepts about how the vapor cloud would behave, and different interpretations

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1/ Ibid.

2/ The nine areas included (1) LNG tanker design and construction; (2) LNG tanker regulations and operations; (3) regulation of LNG terminal operations; (4) certification of LNG projects; (5) safety research on LNG facilities; (6) LNG facility siting; (7) liability for LNG accidents; (8) reliability of LNG supply and (9) LNG pricing policy.

3/ Ibid., p. 58.

of data. Further research could resolve only some--not all--of these differences. 1/ Until there can be some agreement in assumptions to be used in such experiments and until there is some faith that the assumptions are realistic, such investigations, said OTA, cannot be useful for public policy-making. 2/ As for estimating the risks to the public, the use of fault-free analysis and risk analysis, as applied by the FPC to determine whether LNG facilities are safe, is most questionable. Worst of all, such inappropriate use of research techniques leads to a false sense of knowledge about the possible risks. 3/

The GAO report on improvements for LNG import policy

On December 12, 1977, the Comptroller General issued his report to Congress on improvements required for the new national liquefied natural gas import policy. 4/ The Comptroller General advised that the new Presidential policy on imported LNG was inadequate because it did not have the elements needed to be comprehensive and effective. He recommended that policy should be improved by defining clearly goals and objectives for importing natural gas, and by establishing criteria as to what constitutes excessive dependency on imported gas. The report noted but did not discuss the inclusion in the President's policy statement of April 29, 1977, of

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1/ Ibid., p. 58.

2/ Ibid., p. 59.

3/ Ibid., p. 60.

4/ U.S. Comptroller General of the United States. The new national liquefied natural gas import policy requires further improvements. December 12, 1977, 52 p. Report no. EMD-78-19.

prohibitions (presumably for reasons of safety) of dock construction in densely populated areas. It did include the text of a statement of the Energy Resources Council in August 1976 on LNG policy which mentioned the problem of overlapping jurisdiction for siting and safety concerns and said that an ERC LNG task force was to report to the ERC on any expediting actions that could be taken to resolve administrative and legal problems. 1/

Congressional Hearings Relating to LNG Hazards

A principal indicator of congressional interest in hazards of liquefied natural gas and their control is to be found in hearings of various committees of Congress. The Cleveland accident of 1944 did not result in any hearings. The subject came up briefly in 1967 before the Senate Committee on Commerce. Since then there have been eight hearings by two Senate committees and three House committees bearing more or less upon LNG hazards and their control, as shown in Table IV.

For most of these hearings, LNG hazards and their control were incidental to issues of land use, environmental impacts, economic and foreign policy. There follow summaries of these hearings as they relate to control of the hazards of LNG.

1/ The ERC report said that although the Federal Power Commission has jurisdiction over site selection of LNG import facilities, there are fragmented and overlapping responsibilities for LNG siting and safety among Federal aencies and to a certain extent among State governments. The ERC has agreed to address the administrative and legal problems associated with this issue. Working with the FPC and State and local authorities, the ERC LNG Task Force will report to the ERC on any expediting actions that can be taken, or any further analysis needed. Cf., Comptroller General's report, supra, p. 27.

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Table IV

COMMITTEES HOLDING HEARINGS RELATING TO LNG HAZARDS

1967-1977

Year	Senate Committee	House Committee
1967	Commerce	
1973		Merchant Marine & Fisheries Interstate & Foreign Commerce
1974	Commerce	
1975	Commerce	
1976	Interior & Insular Affairs (Joint hearing)	Interstate & Foreign Commerce
1977		Interior & Insular Affairs

April 1967: The Senate Committee on Commerce

On April 19, 1967, the Senate Committee on Commerce opened hearings on legislation to amend the Transportation of Explosives Act to permit the Department of Transportation to regulate natural gas transmitted by pipeline. 1/ Section 3 of the bill (S. 1166) dealt with regulation of gas pipelines and "appurtenant facilities." During the hearings, Senator Lausche, who was concerned about reoccurrence of the kind of LNG accident that had occurred in Cleveland in 1943, questioned whether the bill would cover such

1/ U.S. Congress. Senate. Committee on Commerce. Natural gas pipeline safety regulations. Hearings April 19, 20, August 1, 2, and 3, 1967, 90th Cong, 1st sess., 1976. 426 p.

facilities or only pipelines. Secretary of Transportation Boyd replied that the bill would cover LNG in a storage tank because jurisdiction under the proposed law would extend to "appurtenant facilities" which included storage facilities for LNG. Although S. 1166 as passed by the Senate did not mention "appurtenant facilities," the Secretary was provided with authority to regulate pipeline facilities as well as the transportation of gas by pipeline. 1/ Secretary Boyd also noted that the Department already had safety regulatory authority over LNG when it is moved by train, motor carrier or other vehicle.

July 1973: House Committee on Merchant Marine and Fisheries

During June and July 1973, the Subcommittee on Coast Guard and Navigation of the House Committee on Merchant Marine and Fisheries held hearings on regulation of tankers. 2/ Although the Coast Guard witness did not mention regulation or safety of LNG tankers, this matter was addressed by Mr. Robert J. Blackwell, Assistant Secretary for Maritime Affairs of the Maritime Administration. After briefly sketching Federal regulations applicable to construction and operation of LNG carriers, he commented that the behavior of LNG spills had been investigated in several independent studies, all of which concluded that LNG presented no greater flammability danger than did comparable high-energy petroleum fuels. 3/ Concerning

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1/ Ibid., p. 20.

2/ U.S. Congress. House. Committee on Merchant Marine and Fisheries, Subcommittee on Coast Guard and Navigation. Tanker construction. Hearings, 93d Cong., 1st sess., 1973. 366 p.

3/ Ibid., p. 178.

the risks that an accident with an LNG tanker could release a plume of LNG which might ignite, he said that because of proposed Coast Guard vessel movement controls for LNG ships, it was highly unlikely there would be a casualty which would produce a significant plume, and that past LNG vessel operating experience had produced no such occurrence. 1/ As for a postulated accidental release of the total cargo of an LNG tanker, the fire hazard region would be about one-half mile. If an entire cargo were to be suddenly discharged onto the water, the time duration of the fire hazard would be approximately 30 minutes. 1/

Summing up the accident-free experience of the world's LNG fleet, he said: 2/

> Liquefied natural gas vessels have been operating since the late 1950s. There are a number of them operating in major seaports today, basically from Indonesia and North Africa to such ports as London, Tokyo, and Le Havre, and we have now the experience of some 50 ship-years of operation of liquefied natural gas vessels without a single major accident. There has not been a loss of life involving a liquefied natural gas accident either on the vessel or at the transshipment facility.

Concerning fears of a catastrophic LNG fire resulting from a collision, Mr. Blackwell viewed the risks to be so remote as not to be a valid consideration. Of this he said: 3/

> Mr Chairman, this liquefied natural gas which is released on water or to the air tends to vaporize, and there is a distinct possibility that a vapor cloud could occur, and there is a very remote possibility that that could be ignited. It always stands out there

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1/ Ibid., p. 179.

2/ Ibid., p. 182.

3/ Ibid., p. 183.

> as a threat, but from a mathematical point of view, or from the type of judgments that people have to make about feasibility and safety, the vapor cloud as a source that could damage or destroy buildings, property, and people appears to most who have been involved in this subject so extremely remote as not to be a valid consideration.

Summing up, MARAD believed that liquefied natural gas vessel designs met safety standards adequate to protect the public interest. 1/ MARAD would not have contracted for construction of nine LNG carriers if it had not believed the projects were essentially safe. 2/

While the Subcommittee did not go into LNG safety during the hearings, it later asked some questions for written reply several of which were about LNG tankers. Concerning a question about safety experience with LNG tankers in Boston and New York harbors, MARAD said: 3/

> LNG shipments have been coming into Boston Harbor on a regular basis since late 1968. New York Harbor has received two LNG shipments to date. There has been no accident or serious incident involved in any of the LNG shipments to either port. The Coast Guard has imposed extraordinary requirements on the LNG tankers because of its lack of experience with the cargo and the type of ship. These requirements have included constant surveillance by a Coast Guard vessel, tug assistance into and out of the harbor, minimum visability requirements and a restriction against nighttime operation.

Concerning a study of the odds of an LNG accident in the New York Harbor area, MARAD replied: 3/

> The Arthur D. Little Company has been employed by Eascogas to prepare an analysis of the likelihood of an LNG accident in New York and Providence Harbors. This study was filed with the

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1/ Ibid., p. 181.

2/ Ibid., p. 182.

3/ Ibid., p. 196.

> Federal Power Commission on August 23, 1973, and is now a matter of public record. The Maritime Administration does not presently have the ADL study, but representatives were present during an oral presentation of the report. According to the study, the odds against an LNG accident in the New York area are less than one in every thousand years. This estimate is based upon an analysis of past, present and expected vessel traffic, a breakdown of vessel types and vessel movements within the New York Harbor, and an analysis of the LNG vessel and its ability to withstand the impact of a colliding ship. This study also takes into account the specific characteristics of the cryogenic system employed and the operational speeds to which the vessel will be restricted by reason of harbor constraints and vessel size.

As for the results of the release of an entire cargo of LNG onto the water and the dimesions of any fire that might result, MARAD replied this was a difficult question and mentioned studies which were attempting to assess large spills. It said: 1/

> It is difficult to provide a definitive answer to this question because of the many variables involved. The extent of any fire would depend, for example, upon the number of vessel tanks ruptured, the rate of spill, wind and weather conditions, when ignition takes place and the like. Studies are presently attempting to assess the characteristics of large scale spills of LNG on water, and such technical information will aid in hazard analysis of spills in given situations.

July 1973: The House Committee on Interstate and Foreign Commerce

On July 10, 11 and 12, 1973, the Special Subcommittee on Investigations of the House Committee on Interstate and Foreign Commerce held hearings on the February 10, 1973, Staten Island fire in an LNG storage tank. 2/ In opening the hearings, Chairman Staggers of the Subcommittee

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1/ Ibid.

2/ U.S. Congress. House. Committee on Interstate and Foreign Commerce, Special Subcommittee on Investigations. Staten Island explosion: safety issues concerning LNG storage facilities. Hearings. July 10, 11, 12, 1973. 93d Cong., 1st sess., 1973. 795 p.

noted serious doubts as to whether safety regulations for LNG storage were adequate and, if they were, how well they were being enforced. 1/ About the hearings, he said their purpose was to clarify responsibilities: 2/

> ...We want to find out if present Federal safety standards are inadequate. We want to know whether the Federal Government has committed sufficient resources in money and manpower for proper enforcement. We also want to know if the state of the art in cryogenic storage is sufficiently advanced to provide a reasonable assurance of safety.
>
> * * * * * *
>
> The [Staten Island] tanks have been the subject of considerable controversy and we want a clear understanding of whether the Federal Power Commission has jurisdiction over them. This jurisdictional question affects safety in two ways: First, prime responsibility for enforcement of safety regulations rests directly with the Office of Pipeline Safety [DOT] only when FPC has jurisdiction, otherwise, it rests primarily with State and local agencies; second, there appears to be some disagreement whether the FPC has any authority of its own to consider safety factors in deciding whether to issue certificates to build or to operate LNG tanks.
>
> These questions of jurisdiction and administrative responsibility ought to be resolved, with new legislation, if necessary.

The hearings produced a wealth of information about the uncertainty of Federal responsibility for safety of LNG facilities, with statements from the Comptroller General, the Federal Power Commission, the Department of Transportation, the Department of Labor and the New York City Fire Department. The technical aspects of LNG hazards received little attention.

December 1973: House Committee on Merchant Marine and Fisheries

On December 14, 1973, the Subcommittee on Coast Guard and Navigation of the House Committee on Merchant Marine and Fisheries held a

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1/ Ibid., p. 1.

2/ Ibid., p. 2.

hearing on safety of LNG tankers.1/ Subcommittee chairman Murphy pressed his position on LNG importation in opening the hearing as follows:2/

> I am not, and never have been opposed to the importation of LNG. I am opposed to the unsafe transfer and installation of this potentially hazardous substance when it endangers the safety and well-being of homes, hospitals, schools, and the people who inhabit them.

Mr. Murphy noted that in announcing the hearings, he had called the Coast Guard to explain statements it had made concerning the safety of transporting LNG. Of this, Mr. Murphy said: 3/

> On October 24, 1973, Admiral C. R. Bender, Commandant of the Coast Guard, in response to a letter from the borough president of Richmond, Staten Island, wrote,
>
> ...the Coast Guard believes that our present knowledge of its [LNG's] hazards and the present controls exercised over its movement and handling are sufficient to assure safe importation by water...
>
> I find this statement disconcerting in the face of increasing evidence and concern expressed just in the past few weeks by experts in and out of Congress over the inherent dangers in transporting LNG and the possibility of catastrophic fires and explosions which might result from tanker collisions, especially in crowded port areas.
>
> Of greatest concern are the unknown factors involved in the handling of LNG.
>
> The Maritime Administration told this Subcommittee in October that the Coast Guard has imposed extraordinary requirements on LNG tankers because of its lack of experience with the cargo and the type of ship used to transport it.

1/ U.S. Congress. House. Committee on Merchant Marine and Fisheries. Subcommittee on Coast Guard and Navigation. Safety of LNG tankers. Hearings. December 14, 1973. In Coast Guard Miscellaneous--Part 2. Hearings. October 2, 3, December 14, 1973, July 18, August 28, October 11, 1974. 92d Cong., 1st and 2d sess. 1974, pp. 71-115.

2/ Ibid., p. 71.

3/ Ibid., p. 72.

> With reference to the dimensions of any fire that might result from a massive LNG spill onto the water, MARAD stated it could not provide a definite answer "because of the many variables involved."
>
> The unknowns existing in this area could have mind-boggling consequences for port cities in America...

Summing up, Mr. Murphy said:

> Summing up the unknowns, it appears that we do not know how large or how demolishing an LNG fire explosion due to a spill might be, and we do not, at this time, have the technical knowledge or competence to prevent such a spill from occurring. 1/

The Coast Guard provided the only witnesses for this hearing. The prepared statement of its Commandant contained what is probably the most detailed account of the Coast Guard's responsibilities for LNG safety, its research and analytical efforts and its assessment of hazards to be found in congressional hearings. 2/ Concerning the importation of LNG into New York harbor, which was of particular concern to Chairman Murphy, the Commandant said the risk could be kept acceptably low and that the risks of an LNG terminal may well equal those of petroleum facilities of the same size. The likelihood of a vast methane cloud encompassing much of Staten Island before igniting was extremely remote. The Commandant said: 3/

> ...let me say that, from what is known about the product, what we demand in the way of vessel design and operating standards, what our experience in the Port of Boston has been, the specific requirements necessary to meet the needs of the Port of New York, LNG can be introduced to Staten Island in a manner which will

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1/ Ibid., p. 73.

2/ The Commandant's prepared statement appears at pp. 107-112 of the hearings.

3/ Ibid., p. 111.

keep the hazard level acceptably low, Mr. Chairman, not in guarded fashion, but in the realization that in this, as in most endeavors, we must deal with some degree of uncertainty. In my estimation, the hazards in this case may well equate to those of a similarly large facility dealing in another petroleum product. That is to say that in the untoward event of fire, there could well be severe damage to the immediate area. However, it is my view that the likelihood of a vast methane cloud encompassing large portions of the island before meeting with an ignition source is extremely remote."

Summarizing the Coast Guard's position, its commandant said: 1/

In summary, Mr. Chairman, the Coast Guard feels that with the requirements it has made in respect to the construction of the ships involved, together with those local constraints which the Captain of the Port, New York, will impose in the way of operational procedures to be followed, liquefied natural gas can be imported to the proposed Staten Island terminal.

The Coast Guard then showed a film on LNG hazards, a few questions were asked and the hearing was ended.

March 1974: The House Committe on Interstate and Foreign Commerce report on safety of LNG storage

As a follow-up to its hearings on the Staten Island fire, in March 1974, the Special Subcommittee on Investigations of the House Committee on interstate and Foreign Commerce issued a report on legislative issues relating to the safety of LNG storage. 2/ The Subcommittee underscored the overlaps and gaps in authority for regulation of LNG safety by the Office of Pipeline Safety of the Department of Transportation and by the Federal Power Commission, and indicated that it favored focusing the responsibility

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1/ Ibid., p. 112.

2/ U.S. Congress. House. Committee on Interstate and Foreign Commerce. Special Subcommittee on Investigations. Legislative issues relating to the safety of liquefied natural gas storage. 93d Cong., 2d sess., March 1974, 24 p. (Subcommittee print.)

for safety decision in the OPS. Several excerpts from its report give the flavor of the Subcommittee's conclusions: 1/

> Congress can dissolve much of the jurisdictional conflict between OPS and FPC by amending the Natural Gas Pipeline Safety Act to establish that the OPS has exclusive authority to impose safety regulations on pipeline facilities, including LNG.
>
> But the issue really will not be laid to rest as long as the FPC retains arguable authority to translate its own safety judgments into conditions for the certification of particular LNG facility siting routes. The present FPC has been inclined to exploit this authority to rationalize various safety requirements only remotely related to site or route. To prevent further conflict, it may be necessary for Congress to amend the Natural Gas Act to explicitly provide that for purposes of determining whether an application comports with public convenience and necessity, the question of safety compliance be decided by the OPS, as well as--in the case of LNG port facilities--by the Coast Guard.
>
> This would not give the OPS authority to prescribe site or route; It has testified that it does not need or desire such power. The FPC would still determine whether any particular site or route is consistent with public convenience and necessity, but it would no longer be empowered to stipulate additional safety requirements for an application that is in compliance with OPS and Coast Guard safety standards.

The Subcommittee in concluding its report urged OPS and FPC, as well as the Coast Guard, to form a liaison committee to formulate an agreement to alleviate jurisdictional conflict over the full spectrum of LNG handling and storage matters, and to submit a draft to the Subcommittee prior to adoption. "The resolution of this problem," said the Subcommittee, "would be a major step toward centralized responsibility for safety, substantially simplified and more orderly FPC certification procedures, and, in the long run, more effective regulatory administration." 2/

1/ Ibid., pp. 22-23.

2/ Ibid., p. 24.

June 1974: The Senate Commerce Committee

Hearings before the Senate Commerce Committee on transportation of hazardous materials in June 1974 provided Congress with detailed information on hazards of LNG, on control of these hazards, and on the differing assessments of these controls.1/

The Federal Power Commission described its regulation of the importation of LNG, including the safety aspects of LNG transportation and handling, and FPC's authority over the siting and construction and operation of LNG facilities. The FPC asserted its complete jurisdictional control over the import and export of LNG, as well as its sale for resale and transportation in interstate commerce.2/ As for LNG safety jurisdiction, the FPC described this as a responsibility shared with the Department of Transportation's Office of Pipeline Safety. Both are charged with specific aspects of the regulation of the LNG facilities, with the division of responsibility not clear under the Natural Gas Pipeline Safety Act of 1968. The Commission argued for a continued role, citing a report of the Senate Commerce Committee on the Safety Act as expressing a clear congressional intention that the jurisdiction of the FPC over LNG safety should remain unchanged. The FPC described its efforts to coordinate with other agencies and said that should these efforts fail to achieve a "mutually agreeable

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1/ U.S. Congress. Senate. Committee on Commerce. Transportation of hazardous materials. Hearings. June 12, 13 and 14, 1974. 93d Cong., 2d sess., 1974, 433 p.

2/ Ibid., p. 243.

accommodation of respective responsibilities," it would favor legislation to resolve the conflict. 1/

Another witness concerned with LNG safety was the chairman of the Massachusetts Port Authority. After describing the possible consequences of a large spill of LNG on water or land, he concluded that there was a serious national safety problem associated with the growing importation of LNG. Federal responsibility for LNG safety was divided among Federal agencies and there was no clear overall mandate. While he did not oppose importation and distribution of LNG, he said that the siting of LNG terminals near heavily populated areas of major harbors was a major safety hazard for millions of urban Americans. "The necessity to supply energy which we all need must not be used as an excuse to endanger the lives and property of some who happen to live or work near waterfront areas." 1/ He proposed that it is possible to locate coastal sites where safe LNG facilities could be built which would not threaten many people with disaster.

Coast Guard representatives described its regulation of the transportation of LNG. According to them, the Coast Guard believed that the development, design and construction standards for LNG tankers provide a consistent and reasonable level of safety for the containment and transportation of LNG because Coast Guard requirements would permit LNG to be safely transported in U.S. waters "in a manner which will keep the hazard level acceptably low." 2/ While the hazards from LNG transport

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1/ Ibid., p. 269.

1/ Ibid., p. 272.

may well equate to those of other petroleum products, the likelihood that an accident would produce a vast methane cloud encompassing large portions of an area before igniting was extremely remote. Summarizing its position, the Coast Guard representative said: 1/

> In summary...the Coast Guard feels that with the requirements it has made with respect to the construction of the ships involved, together with local constraints which the captain of the port will and has imposed in the way of operational procedures to be followed, that LNG can be safely transported in our waters.

On the other hand, a marine salvage company expressed its concern over the lack of contingency planning to deal with an LNG tanker casualty, and called for a thorough examination of LNG tanker casualty modes and determination of best responses if an accident should occur. 2/

An east coast company that imports LNG invited the Committee's attention to the public record on LNG safety. This, it said, demonstrated the extremely remote likelihood of either an LNG ship collision which could result in a significant spill or a massive failure of a modern LNG storage tank. 3/ The company expressed its confidence that problems in the transportation and handling of LNG could be overcome and did not present unwarranted risks to the public. One of the most serious problems seen by this company was the jurisdictional conflict among Federal agencies over safety in the transportation and storage of LNG. The company called for legislation to focus safety regulation of LNG ship design

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1/ Ibid.

2/ Ibid., pp. 405-406.

3/ Ibid., p. 423.

and operation and port facilities in the Coast Guard, safety regulation in on-shore, non-marine facilities in the Department of Transportation, and economic regulation in the FPC.

Another natural gas importer, on the west coast, likewise argued that LNG can be imported safely, saying: 1/

> The studies we have made, and the design work we have done, show clearly that we will not endanger the public, our employees, or our neighbors' property by locating our marine terminals for receipt of LNG in or near established harbors. Such locations, in fact, enhance normal day-to-day safety while minimizing industrial intrusions into undeveloped or non-industrial areas.

September 1975: Senate Committee on Commerce

To deal with the overlapping jurisdictions for LNG safety of the Department of Transportation and the Federal Power Commission, the Administration in 1975 proposed an amendment to the Natural Gas Pipeline Safety Act of 1968 2/ to prohibit the FPC from attaching to the issuance certificate of public convenience and necessity a condition that the applicant must comply with safety standards other than those prescribed by the Secretary of Transportation.

On September 25 and 26, 1975, the Subcommittee on Surface Transportation of the Senate Committee on Commerce held hearings on S. 2183 and another bill to amend the Natural Gas Pipeline Act. 3/ LNG hazards and

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1/ Ibid., p. 413.

2/ S. 2183, introduced by Senator Magnuson, by request, July 25, 1975.

3/ U.S. Congress. Senate. Committee on Commerce, Subcommittee on Surface Transportation. Natural Gas Pipeline Safety Act amendments of 1975. Hearings. September 25 and 26, 1975. 94th Cong., 1st sess., 1975, 148 p.

safety measures received substantial attention as the Committee inquired into the failure of the Federal Power Commission and the Department of Transportation to reach agreement on their respective responsibilities for LNG safety regulation.

The Department of Transportation said that its Materials Transportation Bureau had responsibility for the safety regulation of all pipelines and associated storage facilities used for transporting hazardous materials in gas or liquid form, including LNG. 1/ Concerning its interface with the FPC, the Department noted that vagueness in the statutes outlining the natural gas activities of various agencies had created problems of overlapping jurisdiction. 2/ The DOT described its attempts to reach a mutually satisfactory agreement with the FPC concerning safety regulation of interstate gas facilities, particularly LNG facilities. According to DOT, S. 2183 would not have precluded the FPC from taking safety into account in its decisions on a certificate of necessity and conflict would remain. The DOT then described its coordination with the FPC on regulation of LNG safety 3/ but ducked a question about the need for legislation to clarify jurisdiction over LNG facility siting. 4/

1/ Ibid., p. 24.

2/ Ibid., p. 26.

3/ Ibid., p. 93.

4/ The Department of Transportation said: "At the present time the Administration is evaluating the policy relating to the siting of LNG facilities and ascertaining the most effective methods for implementation of a national policy. A decision on this matter is expected in the near future and a request for appropriate additional legislation will be made to implement that decision, if necessary."

The Federal Power Commission reported that it had not worked out the jurisdictional problem with the Department of Transportation because the working agreement which it had submitted to the DOT was not acceptable to them. 1/ The FPC chairman opposed S. 2183 because it would have ousted the FPC from its safety jurisdiction and placed exclusive regulatory authority for LNG safety under the DOT. The public, he said, should be entitled to an FPC review as to whether a proposed LNG project will serve the public interest, or the public convenience and necessity which included an independent determination of safety. Of this, he said, "I submit we should be able to enforce a higher standard, if the evidence before us in a proceeding so demonstrates, in order to provide for the public safety." 1/ As for legislation, the FPC noted that while conflicts in the legislative mandates of the two agencies could be avoided in perhaps every instance by coordination and consultation, there was no doubt that a legislative solution would provide the most clearcut resolution. Therefore, the FPC favored corrective legislation. The chairman proposed his own legislative solution which was to preserve the status quo. The DOT would retain authority to promulgate minimum Federal safety standards; and the FPC, when the public interest so dictated, would retain the authority to apply more stringent safety requirements upon a proper showing. 2/ Concerning the more general question of additional legislation for LNG transportation, siting, and storage, the Commission said that no special legislation was needed. As for the bill, S. 2183 received no further Senate action.

1/ Ibid., p. 102.

2/ Ibid., p. 108.

February 1976: The Senate Committees on Interior and Insular Affairs and on Commerce

On February 17, 1976, the Senate Committees on Interior and Insular Affairs and Commerce held a joint hearing on the transportation of Alaskan natural gas. 1/ Its focus was on the economic viability and feasibility of the proposed pipeline transportation of natural gas from the Prudhoe Bay area into the United States. LNG safety was not mentioned by Chairman Bumpers in his introductory list of issues, but was discussed briefly in these hearings. The Director of the Materials Transportation Bureau, Department of Transportation, described some LNG safety factors and sketched the Department's responsibility for the development and enforcement of comprehensive safety standards for the design, construction, testing, operation and maintenance of pipeline facilities and vessels engaged in the transportation in the United States of natural gas, including LNG. He outlined the Department's regulations for storage and handling of LNG and for design, construction, operation and movement of LNG vessels. No questions were asked on these matters. 2/

In preparation for the hearings, the Committees earlier in January had sent a questionnaire to Federal agencies and private organizations especially interested in this matter. The Committees received 11 replies which were analyzed in a report of the Congressional Research Service subsequently published by the Committees, together with the replies

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1/ U.S. Congress. Senate. Committees on Interior and Insular Affairs and Commerce. The transportation of Alaskan natural gas. Joint hearing. February 17, 1976, part 1, 235 p.

2/ Ibid., pp. 166-168.

themselves.1/ Part of the questionaire inquired into the design and operation techniques to assure safe and continuous operation of the system.2/ Three of the five questions in this part focused on LNG safety. The Federal Power Commission and the Department of Transportation addressed these questions in some detail. Other departments deferred in their replies to the FPC and DOT.

Concerning plans or procedures to prevent or deal with LNG tanker collisions or other LNG handling accidents, both the FPC and the DOT described their regulations in detail. Concerning questions about technology

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1/ U.S. Congress. Committees on Interior and Insular Affairs and Commerce. The transportation of Alaskan natural gas. Joint hearing. February 17, 1976. 94th Cong., 2d sess. Part 2, Appendix, pp. 237-1515.

2/ Part III-E of the questionnaire asked the following: What are the design and operation techniques to assure safe and continuous operation of Alaskan natural gas transportation systems? (Cf., Hearings, Appendix I, pp. 276-277.)

(1) What is the relationship between the Federal Power Commission and the Department of Transportation with respect to safety standards during gas pipeline construction and operation?

(2) What are the probable and worst case estimates of injury and damage of natural gas pipeline accidents?

(3) Which State and/or Federal agencies have jurisdiction over LNG terminal siting with respect to safety, distance from population centers, and ship traffic control?

(4) What plans or procedures have the responsible agencies or the applicant devised to prevent or deal with LNG tanker collisions or other LNG handling accidents? What is the best available technology to minimize the risk of an LNG accident and to deal with serious LNG accidents?

(5) What are the probable and worst case estimates of injury and damage that could result from an LNG tanker or terminal accident? What are the owners' liabilities for such an accident? Are existing liability laws adequate to provide compensation for all damages resulting from a probable and worst case accident?

to deal with LNG accidents, neither provided information on the best available technology to minimize the risk of an LNG accident or to deal with a serious accident. Concerning probable and worst case estimates for injury and damage from a major LNG accident, the FPC recognized that a major accident was possible, but concluded it would be unlikely. Also, because of technical differences between one accident and another, it was not possible to predict damage or casualties from a particular leak or rupture. 1/ The DOT took a similar position, replying: 2/

> The present state of knowledge does not permit making quantitative estimates of injury and damage for LNG tanker accidents. There have been and are sizable R & D efforts by the Coast Guard to develop this capability in connection with development of a risk analysis methodology and in investigation of LNG hazards. A number of studies have been sponsored by government and industry but results have varied widely. Therefore, this question can be answered only qualitatively.

According to the DOT, the most probably LNG tanker accident would cause a small release of LNG resulting in a small fire which could be extinguished or in minor structural damage to the ship. Injury and damage probably would be confined to operating personal and industrial property.

As for a worst case accident, DOT conceived of one in which the contents of one storage tank in an LNG tanker, about 37,500 cubic meters of LNG, would be released instantaneously. Ignition of the gas would produce severe effects that would be localized to the general vicinity of the vessel,

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1/ Hearings, op. cit., p. 366.

2/ Ibid., p. 645.

with thermal radiation to the surroundings being the threat to the public and other vessels and facilities. Of this, DOT said: 1/

> The formation of a large flammable cloud over populated areas with delayed ignition is not envisioned. Fire engulfment of the vessel would not cause other tanks to fail because they are heavily insulated and have pressure relief systems that are sized for this degree of fire exposure. Even if they did ultimately fail, the failures would be sequential, thus extending the duration of the fire but not the intensity. The hazards of the reaction of LNG and water--the flameless explosion phenomena and catastrophic failure of a hull in contact with an LNG pool on water are believed to be minor compared with the primary flammability hazard...major damage to the ship with subsequent large releases of LNG is not considered to be credible.

The DOT discounted both the Cleveland incident of 1944 and the Staten Island explosion of 1973 as basis for concern over LNG hazards. Concerning Cleveland, DOT said that if current materials, technology and design criteria had then been available, the Cleveland tank failure would probably not have occurred and the escaping LNG would have been contained in a secondary impounding area. 2/ As for the Staten Island fire, the DOT classified this as an industrial accident rather than an operational failure. 2/

Commenting further, DOT said: 1/

> Although, as discussed above, the Cleveland and Staten Island incidents are not representative of the risks associated with the operation of present LNG facilities, the spectacular nature of these accidents resulted in widespread negative publicity for LNG. Unfortunately, current advances in cyrogenic technology have not received an equal amount of public attention.

1/ Ibid., p. 646.

2/ Ibid., p. 647.

1/ Ibid., p. 658.

As for risk analysis, estimates of probable damage and injury were highly uncertain because of insufficient reference data. The Department had not prepared a risk analysis of LNG terminals and was not able to estimate probable deaths or injuries from a major accident. It agreed that a worst case estimate could be made by risk analysis for a particular facility. However, the Department could not make such estimates because it had not conducted risk analyses for LNG facilities. 1/

March 1976: The Senate Committees on Interior and Insular Affairs and on Commerce

The Senate Committees on Interior and Insular Affairs and Commerce on March 24 and 25, 1976, concluded their joint hearings on transportation of Alaskan natural gas. 2/ LNG hazards were briefly mentioned and discounted by the El Paso Alaska Company 3/ which called attention to the Coast Guard report that LNG is among the safest seagoing operations. 4/ The Sierra Club preferred a pipeline route along the Fairbanks-Alcan highway corridor because of serious problems it saw with LNG transport and facility siting. 5/ The Chairman of the Massachusetts Port Authority described the experience of the Port of Boston as the only U.S. port then

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1/ Ibid., p. 649.

2/ U.S. Congress. Senate. Committees on Commerce and on Interior and Insular Affairs. Transportation of Alaskan natural gas. Joint hearings. March 24, 25, 1976. 94th Cong., 2d sess., 1976, part 3, pp. 1517-2030.

3/ Ibid., p. 1560.

4/ Ibid., p. 1570.

5/ Ibid., p. 1787.

receiving LNG in significant quantities. He emphasized the hazards of an accidental spill of LNG from LNG tankers or LNG storage tanks and explained his conclusion that there is a serious national safety problem associated with the growing importation of LNG into the United States. He called attention to uncoordinated Federal authority and recommended a voice for local and State officials in approval of sites for LNG terminals. 1/

May and August 1976: House Committee on Interstate and Foreign Commerce

On May 17, 18, 19 and August 6, 1976, the House Committee on Interstate and Foreign Commerce, Subcommittee on Energy and Power, held hearings on bills relating to the construction and operation of an Alaskan Natural Gas Transportation Route. 2/ Most of the testimony focused upon economic, regulatory, environmental and international matters, with LNG safety touched upon briefly. Chairman Dingell questioned the Federal Power Commission about its authority or that of other agencies to assure proper siting and safety for LNG facilities, mentioning the Staten Island explosion as cause for concern. The FPC in reply outlined in detail its authority regarding LNG safety regulations. 3/

1/ Ibid., pp. 1841-1845.

2/ U.S. Congress. House. Committee on Interstate and Foreign Commerce. Subcommittee on Energy and Power. Hearings. Alaskan natural gas transportation. May 17, 18, 19 and August 6, 1976. 94th Cong., 2d sess., 1976, 719 p.

3/ Ibid., pp. 177-179.

The El Paso Alaska Co. statement noted that with respect to LNG technology, the U.S. Coast Guard had reported that LNG is among the safest seagoing operations being carried on. 1/

LNG safety came up again in a panel discussion of Federal witnesses which called attention to a possible role for the Department of Interior for safety and related matters at LNG shore facilities located on Federal lands. 2/

Environmental groups mentioned LNG safety but did not pursue it. For example, the Wilderness Society noted that an all-Alaska LNG tanker proposal raised serious questions regarding LNG tanker safety and would increase LNG tanker activity and LNG facilities siting which was why it favored a wholly overland route. 3/ The Environmental Policy Center called attention to the significant public safety hazard of LNG transportation, storage, and processing. 4/ Friends of the Earth said they were not certain about the future of this high-risk, high-cost technology, but believed that

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1/ Ibid., p. 376.

2/ Ibid., p. 449.

3/ Ibid., p. 502.

4/ Ibid., p. 507. Ms. Barbara Heller of the Environmental Policy Center said: "The public safety hazards of LNG transportation, storage, and processing are significant. LNG technologies are considered to be low-probability, high-risk technologies. Comprehensive siting criteria for LNG facilities have never been established. Although a great deal is now known about liability and insurance schemes for oil spills and many States have oil spill liability laws, very little is known about liability and insurance for LNG accidents, whether they result from shipping, transfer operations, storage, or processing operations. The safety implications of LNG siting must be thoroughly examined, and comprehensive siting criteria must be developed."

the safety questions and siting issues are best decided by the regions which must bear the costs. 1/

March-April 1977: The House Committee on Interior and Insular Affairs

During March and April 1977, the Subcommittee on Indian Affairs and Public Lands of the House Committee on Interior and Insular Affairs held oversight hearings on transportation of Alaskan natural gas. 2/ While most of the hearings focused upon Indian rights and on economic and environmental aspects, LNG safety was mentioned a few times.

The Maritime Trades Department of the AFL-CIO favored the combined pipeline-LNG tanker system for transporting LNG to the west coast. The union saw no significant hazards in LNG shipment by tanker, saying that the ships were highly sophisticated and had every conceivable safety feature built into them, and pointing out that the union members who operate these ships would be the ones exposed to whatever hazards exist. 3/ "We just think that from the standpoint of safety, anything that the human mind and technology can devise to go into making these ships safe is going to be done on them." 4/

The Sierra Club noted that an overland route would avoid the crucial LNG siting and safety problems, but did not elaborate. 5/ The Environmental

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1/ Ibid., p. 543.

2/ U.S. Congress. House. Committee on Interior and Insular Affairs, Subcommittee on Indian Affairs and Public Lands. Transportation of Alaskan natural gas. Oversight hearings. March 17, 18 and 29, April 5, 1977. 95th Cong., 1st sess., 1977, 535 p.

3/ Ibid., p. 166.

4/ Ibid., p. 167.

5/ Ibid., p. 227.

Policy Center said that of the three proposals for transport of natural gas to the United States, the most insidious was that involving LNG: 1/

> ...El Paso's LNG transportation and processing scheme not only severely endangers human populations but it would tremendously stimulate and become the main link in the worldwide transportation of foreign natural gas to the United States.

However, the Center provided no additional information on LNG hazards.

Congressional Record Indications of Interest in the Hazards of Liquefied Natural Gas

A third source of information for Congress on the hazards of LNG and their control is to be found in material appearing in the Congressional Record. From May 23, 1969 to November 1977, thirteen Members of Congress have made statements or placed materials in the Record relating to this matter. Of these, five were statements in support of bills proposed by the Members involved. Considering the enormous amount of other materials appearing in the Congressional Record during these eight years, these few items would indicate correspondingly little general congressional interest to date in control of the LNG hazards. Table V presents a chronological listing and identification of the 13 items in the Congressional Record.

1/ Ibid., p. 402.

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Table V

CHRONOLOGICAL LISTING OF ITEMS IN THE CONGRESSIONAL RECORD RELATING TO SAFETY OF LIQUEFIED NATURAL GAS: 1969 TO 1971

May 23, 1969: Sen. Inouye inserted in the Congresqional Record a statement on a national policy on LNG by Carl Bagge, FPC Commissioner, before the Sixth Mid-Pacific Gas Marketing Conference, Honolulu, Hawaii. (p. S13611)

March 22, 1972: Rep. Anders of Tennessee addressed the House on LNG ships and facilities, in support of H.R. 13832, to authorize Federal funding of an LNG tanker fleet, which he introduced March 15, 1972. (p. H9642)

June 29, 1972: Sen. Bellmon of Oklahoma made a floor statement on LNG imports from Algeria and an "illogical" FPC decision to permit imports of LNG from Algeria. (p. S23226)

February 20, 1973: Sen. Dominick made a floor statement on how the United States can end industrial disasters, with specific reference to the Staten Island fire in an LNG tank, and placed in the Record an editorial from the New York Times of February 13, 1973, on this accident. (p. S4535)

February 20, 1973: Rep. Wolff introduced H.R. 4430, to suspend all LNG imports by ship until the Coast Guard and other Federal agencies submit to Congress a comprehensive evaluation of associated hazards and a comprehensive plan for preventing or minimizing these hazards, and Congress authorizes resumption. (p. R4522)

August 22, 1974: Sen. Abourezk placed in the Record an article by Bryan Silcock from the London Times of August 11, 1974, "Blast triggers fear of floating bomb clouds from big gas tankers." (p. S29871)

March 4, 1975: Rep. Richmond placed in the Record his statement on LNG before the Federal Power Commission, calling for a moratorium on storage and transportation of LNG into New York City pending study of safety hazards. (p. R5191)

March 6, 1975: Rep. Murphy introduced his bill, H.R. 4440, to require the Coast Guard to select LNG sites adjacent to U.S. navigable waters, with a supporting statement. (p. R5544)

February 16, 1976: Sen. Bumpers announced hearings on transportation of Alaskan natural gas and placed in the Record the text of a questionnaire sent to prospective witnesses concerning major issues, including LNG safety. (p. S1584, daily edition)

January 31, 1977: Sen. Stevens placed in the Record an article from the Washington Star concerning LNG transport from Alaska to Massachusetts. (p. S1658, daily edition)

February 9, 1977: Rep. Murtha made a statement in support of transport of natural gas from Alaska by a combination of pipeline and LNG tankers. (p. E700, daily edition)

April 19, 1977: Sen. Stevens placed in the Record an editorial of the Fairbanks News Miner that discusses the safety of LNG transportation by tanker. (p. S5928, daily edition)

November 1, 1977: Sen. Pell introduced S. 2273, a bill to confer on the Secretary of Energy jurisdiction over construction permits and operating licenses for LNG facilities, with remarks. (p. S18343, daily edition)

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APPENDIX I

CHRONOLOGY OF SELECTED LEGISLATIVE AND OTHER EVENTS RELATING TO CONTROL OF HAZARDS FROM LIQUEFIED NATURAL GAS

1938: The Natural Gas Act of 1938 was approved by President Roosevelt.

1939: The Hope Natural Gas Company erected a pilot liquefaction plant for natural gas at its Cornwell compressor station in West Virginia.

1940: The Dangerous Cargo Act was approved by President Roosevelt.

1941: The East Ohio Gas Company built a peakshaving plant in Cleveland, Ohio.

October 20, 1944: An LNG storage tank of the East Ohio Gas Company in Cleveland, Ohio, ruptured, spilling 6,200 cubic meters of LNG into adjacent streets and sewers. The resulting fire and explosions caused 128 deaths, 300 injuries and about $7 million in property damage.

February 1946: The Bureau of Mines of the Department of the Interior issued its report on the Cleveland fire.

June 19, 1948: The Admiralty Extension Act of 1948 was approved by President Truman.

May 22, 1953: The Submerged Lands Act was approved by President Eisenhower.

August 7, 1953: The Outer Continental Shelf Act was approved by President Eisenhower.

1957: The Coast Guard issued the first tentative rules on non-pressure vessel liquefied gas carriers.

January 1959: The first export shipload of LNG left the United States in the Methane Pioneer, a specially constructed tanker, for England.

1964: First commercial LNG trading took place.

October 15, 1966. President Johnson approved the Department of Transportation Act.

August 12, 1968: President Johnson approved the Natural Gas Pipeline Safety Act of 1968.

1969: Japan imports large volume of Alaskan LNG.

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January 1, 1970: President Nixon approved the National Environmental Policy Act of 1969.

December 29, 1970: President Nixon approved the Occupational Safety and Health Act of 1970.

January 10, 1971: The Bureau of Mines, Department of the Interior, issued its reports on hazards associated with spillage of LNG on water which mentioned mysterious explosions that sometimes occur in this type of situation.

March 1, 1972: The Federal Water Pollution Control Act amendments of 1972 were approved by President Nixon.

March 15, 1972: Mr. Anderson introduced H.R. 13832, a bill to authorize the Secretary of Commerce to contract with U.S. shipbuilders, or those of the Commonwealth of Puerto Rico, for the construction, outfitting and equipping of no more than 40 liquefied natural gas ships, with delivery not later than January 1980.

April 17, 1972: Mr. Dulski introduced H.R. 14379, identical to H.R. 13832, above.

May 22, 1972: Mr. Anderson introduced H.R. 15098, identical to H.R. 13832, above.

July 10, 1972: President Nixon approved the Ports and Waterways Safety Act of 1972.

September 30, 1972: The Maritime Administration signed the first subsidy contracts for construction of LNG carriers, for six carriers of 125,000 cubic meters capacity each.

October 18, 1972: President Nixon approved the Federal Water Pollution Control Act of 1972.

October 23, 1972: President Nixon approved the Marine Protection, Research and Sanctuaries Act of 1972.

October 27, 1972: President Nixon approved the Coastal Zone Management Act of 1972.

February 10, 1973: A fire of unknown origin broke out in the LNG storage tank of Texas Eastern Transmission Corporation, located in the Bloomfield section of Staten Island, New York. The fire caused the death of 40 men who were working in the tank. Physical damage included the complete destruction of the internal components of the tank, the dome and associated piping and the fire fighting apparatus, and substantial damage to a nearby roadway.

February 20, 1973: Mr. Wolff introduced H.R. 4430, a bill to suspend the importation of liquefied natural gas and the construction of new storage facilities for LNG until a thorough investigation was made of the hazards associated with the marine transportation, delivery and storage of such gas and of other actions to prevent or minimize hazards.

March 15, 1973: Mr. Wolff and nine cosponsors introduced H.R. 5755, identical to H.R. 4440, above.

July 10, 11, 12, 1973: The Special Subcommittee on Investigations, House Committee on Interstate and Foreign Commerce, held hearings on the Staten Island explosion and safety issues concerning LNG storage facilities.

December 14, 1973: The House Committee on Merchant Marine and Fisheries, Subcommittee on Coast Guard and Navigation, heard the Coast Guard discuss standards for LNG shipment and safety measures for handling LNG at the Staten Island, N.Y., LNG terminal.

March 1974: The Special Subcommittee on Investigations, House Committee on Interstate and Foreign Commerce, issued its report on legislative issues relating to the safety of LNG storage.

June 12-14, 1974: The Senate Committee on Commerce held hearings on S. 2064, to amend the laws governing the transportation of hazardous materials.

January 3, 1975: President Ford approved the Dangerous Cargo Act.

March 3, 1975: Congressman Richmond of New York appeared before the Federal Power Commission to oppose the transportation and storage of LNG in New York City and to call for an FPC moratorium on storage and transportation of LNG in New York City until safety studies could be made.

March 6, 1975: Mr. Murphy introduced H.R. 4440, a bill to amend the Port and Waterways Safety Act of 1972 to require the Secretary of the Department in which the Coast Guard is operating to certify certain sites suitable for the location of liquefied natural gas storage terminals and to prohibit the issuance of a certificate of public convenience and necessity by the Federal Power Commission without such certification.

September 25, 26, 1975: The Senate Commerce Committee held hearings on the Natural Gas Pipeline Safety Act amendment of 1975 that were intended in part to resolve the jurisdictional dispute between the FPC and the DOT.

February 1, 1976: The U.S. Coast Guard published its report "Liquefied Natural Gas--Views and Practices, Policies and Safety."

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February 17, 1976: The Senate Committees on Interior and Insular Affairs and Commerce held a joint hearing on the transportation of Alaskan natural gas. LNG safety aspects were briefly mentiond.

February 26, 1976: The Senate Appropriations Committee, Subcommittee on DOT Appropriations, placed in the record of its hearings the Coast Guard report on LNG.

February 26, 1976: President Ford in an energy message to Congress announced a national policy designed to limit importation of LNG to about 1 trillion cubic feet a year. The Energy Resources Council was directed to review each proposed project where LNG would be imported, "balancing the need for supplies with the need to avoid excessive dependence."

March 1976: The Department of the Interior issued its final environmental impact statement on the Alaskan natural gas transportation system.

March 4, 1976: The Senate Committee on Commerce, Subcommittee on Surface Transportation, held a hearing on amendments to the Hazardous Material Transportation Act.

March 24, 25, 1976: The Senate Committee on Interior and Insular Affairs and the Committee on Commerce held hearings on the transportation of Alaskan natural gas.

April 1976: The Federal Power Commission issued its draft environmental impact statement on the Alaskan natural gas transportation system.

May 17, 18, 19, 1976: The House Committee on Interstate and Foreign Commerce, Subcommittee on Energy and Power held hearings on Alaskan natural gas transportation.

August 5, 1976: The President's Energy Resources Council announced an elaboration of the President's previously announced limitation on LNG imports. Concerning safety and siting concerns, the ERC noted there still were overlapping responsibilities for LNG safety and siting among Federal agencies and some State governments. A Federal Interagency Task Force was to work with the FPC and with State and local authorities to resolve such problems.

August 6, 1976: The House Committee on Interstate and Foreign Commerce, Subcommittee on Energy and Power, concluded its hearing on Alaskan natural gas transportation.

October 22, 1976: President Ford approved the Alaska Natural Gas Transportation Act of 1976, P.L. 94-586.

October 26, 27, 1976: The Federal Energy Administration held hearings on siting and regulation of LNG facilities. Consumer and industry representatives said that unless national guidelines to deal with safety and other issues were developed, the Federal Power Commission would continue to delay approval of LNG terminal sites.

February 17, March 17, 18 and 29, and April 5, 1977: The House Committee on Interior and Insular Affairs, Subcommittee on Indian Affairs and Public Lands, held oversight hearings on methods of transporting Alaskan natural gas.

April 29, 1977: The President issued his policy on imported liquefied natural gas, which calls for a case-by-case analysis of each import project to consider the reasonableness of price, risks of dependence on foreign suppliers, safety conditions, and costs.

May 1, 1977: The Federal Power Commission submitted to the President its recommendation for a choice among three competing Alaskan natural gas transportation systems.

May 3, 1977: Mr. Dingell introduced H.R. 6844, a bill to regulate the siting, design, construction and operation of facilities for use in the transportation, storage and conversion of liquefied natural gas. Referred to the Committee on Interstate and Foreign Commerce.

July 13, 1977: Mr. McClosky introduced an amendment (No. 460) to H.R. 4963.

September 22, 1977: President Carter sent to Congress his decision and report on an Alaskan natural gas transportation system.

September 23, 1977: The FPC staff recommended making Rhode Island the site of a major LNG import terminal.

September 28, 1977: The Office of Technology Assessment forwarded to Congress the results of its assessment of the transportation of LNG which was requested by the National Ocean Policy Study of the Senate.

October 1, 1977: The Department of Energy came into being.

October 27, 1977: Mr. Beard of Rhode Island introduced H.R. 9773, a bill to provide that no certificate for the construction or extension of any LNG facility may be granted unless the State or States in which such facilities are located have been approved by the affected States. Referred to the Committee on Interstate and Foreign Commerce.

November 1, 1977: Senator Pell introduced S. 2273, a bill to confer on the Secretary of Energy jurisdiction over construction permits and operating licenses for LNG facilities. Referred to the Committee on Energy and Natural Resource.

November 18, 1977: An FERC administrative law judge granted initial approval to a proposal allowing Distrigas Corporation of Boston, Mass., to triple the amount of LNG imports from Algeria to about 43 billion Btu per year beginning in 1978.

December 12, 1977: The Comptroller General completed his report to Congress on the new national liquefied natural gas import policy and required further improvements.

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APPENDIX II

LIST OF CONGRESSIONAL HEARINGS AND REPORTS RELATING TO LIQUEFIED NATURAL GAS HAZARDS

U.S. Congress. House Committee on Interior and Insular Affairs. Transportation of Alaskan natural gas. Oversight hearings. March 17, 18 and 29, and April 5, 1977. 95th Cong., 1st sess., 1977, Part II, 535 p.

U.S. Congress. House. Committee on Interstate and Foreign Commerce. Special Subcommittee on Investigations. Staten Island explosion: safety issues concerning LNG storage facilities. Hearings. July 10, 11, and 12, 1973. 93d Cong., 1st sess., 1973, 795 p.

----Legislative issues relating to the safety of liquefied natural gas storage. 93d Cong., 2d sess., March 1974, 24 p. (Subcommittee print.)

----Subcommittee on Energy and Power. Hearings. Alaskan natural gas transportation. May 17, 18, and 19, and August 6, 1976. 94th Cong., 2d sess., 1976, 719 p.

U.S. Congress. House. Committee on Merchant Marine and Fisheries. Subcommittee on Coast Guard and Navigation. Safety of LNG tankers. Hearing. December 14, 1973. In Coast Guard Miscellaneous, Part 2, Hearings. October 2 and 3, December 14, 1973; July 18, August 28, October 11, 1974. 93d Cong., 1st and 2d sess., 1975, 218 p.

----Tanker construction. Hearings. June 6, 7, July 18, 19, 1973. 93d Cong., 1st sess., 1973. 366 p.

U.S. Congress. Senate. Committee on Commerce. Natural gas pipeline safety regulations. Hearings, April 19 and 20, August 1, 2, and 3, 1967. 90th Cong., 1st sess., 1976, 426 p.

----Subcommittee on Surfact Transportation. Natural Gas Pipeline Safety Act amendments of 1975. Hearings. September 25 and 26, 1975. 94th Cong., 1st sess., 1975, 148 p.

----Transportation of hazardous materials. Hearings. June 12, 13, and 14, 1974. 93d Cong., 2d sess., 1974, 433 p.

U.S. Congress. Senate Committees on Interior and Insular Affairs and Commerce. The transportation of Alaskan natural gas. Joint hearing February 17, 1976. 94th Cong., 2d sess., 1976. Part 1, pp. 1-235; Part 2 - Appendix, pp. 236-1515.

U.S. Congress. Senate. Committees on Commerce and Interior and Insular Affairs. Transportation of Alaskan natural gas. Joint hearing March 24 and 25, 1976. 94th Cong., 2d sess., 1976. Part 3, pp. 1517-2030.

APPENDIX II

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LIQUEFIED NATURAL GAS: HAZARDS, SAFETY REQUIREMENTS, AND POLICY ISSUES

Paul F. Rothberg
Analyst in Physical Sciences
Science Policy Research Division

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This is a preprint of a chapter that will appear in volume III of the National Energy Transportation study prepared by the Congressional Research Service for the Senate Committee on Energy and Natural Resources and the Senate Committee on Commerce, Science, and Transportation. Until volume III is published, this preprint is not for quotation or attribution.

3.5.12. LIQUEFIED NATURAL GAS: HAZARDS, SAFETY REQUIREMENTS, AND POLICY ISSUES */

Importation of liquefied natural gas (LNG) into the lower 48 States from Alaska or foreign sources is expected to increase. This fuel would supplement the Nation's declining reserves of natural gas. However, LNG poses significant safety risks which may require review of existing procedures and regulations for its shipment, handling, and storage. New guidelines for the siting of LNG storage terminals, legislation to reassign and coordinate Federal responsibilities over LNG systems, and the reappraisal of national policies affecting the supply of and demand for LNG may be necessary before a large number of plants are constructed.

3.5.12.1. Introduction

In recent years, Congress has repeatedly directed attention to the adequacy of the Nation's long-term gas supply. Experts have noted that prospects for meeting demands for natural gas through 1985 appear to be worsening. For example, only experimental quantities of synthetic natural gas (SNG) from oil shale or coal are likely to be produced before 1985. Only small quantities of SNG can be produced from petroleum feedstocks. The outlook for obtaining increasingly large quantities of gas from the Outer Continental Shelf is uncertain.

Accordingly, attention is focusing on the use of liquefied natural gas (LNG) as a means to supplement conventional gas supplies. The huge gas reserves located in about 20 foreign countries and Alaska can be transported in specially-designed tankers to the conterminous 48 States if it is cooled and liquefied; a process that compacts natural gas to

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*/ Prepared by Paul Rothberg, Analyst, Science Policy Research Division.

1/600 of its volume. LNG can be stored in large quantities until it is needed and can be transported to places that cannot be reached by pipelines. Many gas companies store surplus gas during seasons of low use as LNG and regasify the liquid to meet demands when necessary. Thus, LNG systems are versatile and can help meet gas demands by supplying fuel when it is needed.

3.5.12.2. Existing and Expected LNG Receiving Facilities

The technology for importing, receiving, storing, and regasifying LNG is a proven technology. A considerable international trade in LNG already exists: Japan imports about 80 percent of its gas in liquid form, Western Europe 5 percent, and the United States somewhat less than .1 percent. 1/

The quantity of LNG imported into the lower 48 States is expected to increase significantly over the next 10 to 15 years. It is not possible to determine accurately the exact quantity of LNG that will be imported. New projects are continually being planned; announced projects are frequently cancelled; contracts are continually terminated and renewed. "Given these uncertainties, it is virtually impossible to know, with a high degree of reliability, how much and where LNG will be used in the U.S. during the 1980-1990 time frame. 2/

1/ Drake, Elisabeth and Robert C. Reid. The Importation of Liquefied Natural Gas. Scientific American, v.236, April 1977:22.

2/ Fink, R.J., B.A. Bancroft, and T.M. Palmieri, The Strategic Petroleum Reserve and Liquefied Natural Gas Supplies: Final Report. TRW Energy Systems Planning Division, Virginia, 1977:35.

Even though plans for LNG facilities are frequently changing, useful information can be obtained by reviewing current activities of the LNG industry. In the United States, there is one LNG receiving facility in operation; two nearing completion; and up to six proposed.

Distrigas Corporation was the first U.S. company to import large quantities of LNG. Their effort began in 1971, with a project to bring 15 billion cubic feet of gas per year from Algeria to Everett, Mass. In 1976, Distrigas received only 11 cargos of LNG which totalled 10.8 trillion Btus. In April 1976, this Corporation signed a new agreement to import approximately 115 million cubic feet of gas daily for 20 years beginning in 1978. 3/

Another LNG facility, which cost over $100 million, was completed in 1974, at Staten Island, New York. Because of its location near heavily populated areas and other safety, regulatory, and environmental concerns, this plant has not yet received all of its required operating permits and importation of gas may not be forthcoming for some years, if ever. 4/ This plant, now owned by Public Service Electric and Gas Company of New Jersey, is now "mothballed", and has no supply or shipping contracts. 5/

A fleet of nine newly-built LNG ships, owned by El Paso Natural Gas Company, is soon expected to begin transporting LNG from Algeria to Cove Point, Maryland, and to Elba Island, Georgia. These ships

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3/ Daniel, E.J. and P.J. Anderson. International LNG Prospects Continue Progress as New Plans Evolve. Pipeline and Gas Journal, June, 1977:30.

4/ Personal communication with Richard Norman, of Energy Storage Ventures, 1977.

5/ Personal communication with Ben Bakerjian of Public Service Electric and Gas Co. of New Jersey, 1977.

are capable of delivering a combined average of one billion cubic feet per day to the two facilities. Another U.S. terminal is expected to be built near Lake Charles in Calcasieu Parish, Louisiana. This terminal may receive about 168 billion cubic feet of LNG annually from Algeria for 20 years, starting around 1980, assuming the plant proceeds as scheduled.

The long-term need for natural gas may give rise to additional terminals on the North Atlantic, Gulf and West coasts for receiving LNG from Algeria, Nigeria, Trinidad, Indonesia, Libya, Iran, U.S.S.R., or Alaska.

Plans for these terminals are detailed in Table I.

The demand for LNG, as well as the availability of this fuel from abroad, is likely to increase. The Congressional Research Service has projected the following amounts of LNG imports: .5 trillion cubic feet (tcf) in 1980, 1.2. tcf in 1985, and 1.7 tcf in 1990. Assuming these figures prove correct, LNG would contribute 2.6%, 6.1%, and 8.1% of total gas supply in 1980, 1985, and 1990, respectively. (CRS's projection assumed that no major institutional barrier would interfere with the siting of LNG terminals in the coastal zone). 6/

The likelihood of large scale LNG imports depends not only on the Federal import policy adopted and its considerations of source and dependability, but also on the economics of using LNG. Substantial quantities of LNG imports are unlikely at prices competitive with the current prices of domestic natural gas, because of the combination of high costs of transportation and processing, combined with the desire

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6/ U.S. Congress. House and Senate. Committees on Energy and Natural Resources, Commerce, Science and Transportation, and Interstate and Foreign Commerce. Project Interdependence: U.S. and World Energy Outlook Through 1990. By the Congressional Research Service, Library of Congress, (Washington, D.C., U.S. Govt. Print. Office, June 1977) p. 29.

TABLE I. PLANNED U.S. IMPORT/RECEIVING TERMINALS */

	STORAGE CAPACITY MMcf	MBbl	REGASIFICATION CAPACITY	MMcfd- RUNS	TYPE OF STORAGE CONTAINER TYPE		STORAGE CONTRACTOR Preload/ Walsh	SYSTEMS CONTRACTOR Ralph M. Parsons Co.	YEAR OF OPERATION 1973/75 PSE&GNJ to operate for Eascogas imports former Distrigas of N.Y. facility
PUBLIC SERVICE ELECTRIC AND GAS CO. of NEW JERSEY Staten Island, N.Y.	6000 (2x900)	1800	360	4 at 90	Direct Fluid	Prestressed concrete			
COLUMBIA LNG CORP. & CONSOLIDATED SYSTEM LNG CO. Cove Point, Maryland	5000 (4x375)	1500	1000 200	10 at 100 2 at 100	Submerged Inter Fluid	Aboveground aluminum	PDM	Pullman Kellogs & Raymond Technical	1977 -- Base Load Plant
ALGONQUIN LNG INC. (EASCOGAS LNG.,INC. Providence, R.I.	6000 (3x600)	1800	300 375	3 at 100 3 at 125	Direct Fluid Seawater	Aboveground 9% nickel	CBI	CBI	1973 -- 1st tank 1975 -- 2 addit.tanks planned
NATURAL GAS PIPELINE CO. OF AMERICA (Peoples Gas) Ingleside, Tex.	5500 (2x800)	1600	400	NA	NA	Aboveground 9% nickel	NA	NA	1983 -- planned
TRUNKLINE LNG CO. Lake Charles La.	6000 (3x600)	1800	NA	NA	NA	NA	NA	Pullman Kellog Co	1980 -- planned
SOUTHERN ENERGY CO Elbs Island, Ga.	4000 (3x400 tanks)	1200	540	5 at 108	Submerged	Aboveground aluminum	CBI	Betchel Inc.	1977 -- U.C.: Base Load Plant
TEXAS EASTERN TRANS. CORP. & TENNESSEE GAS TRANS. CO. West Deptford, N.J.	NA	NA	NA	NA	NA	NA	NA	NA	NA -- planned
WESTERN LNG TERMINAL CO. Terminal Island, Los Angeles Harbor, Cal.	7700 (4x550)	2200	5000	40 at 100 10 at 100	Direct Seawater Submerged	Aboveground 9% nickel	NA	Fluor	48 months after approval
WESTERN LNG TERMINAL CO. Port Hueneme, Oxnard, Cal.	7700 (4x550)	2200	4600	36 at 100 10 at 100	Direct Seawater Submrgd	Aboveground 9% nickel	NA	Fluor and Raymond Technical	48 months after approval
WESTERN LNG TERMINAL CO. Port Conception, Cal.	7700 (4x550)	2200	3300	28 at 100	Direct Seawater	Aboveground 9% nickel	NA	Fluor	48 months after approval
TENNECO LNG CO. West Deptfortd, N.J.	9100	2600	NA	NA	Above ground	NA	NA	NA	1983 -- planned
EL PASO TERMINAL LNG. Port O'Connor, Texas	4168 (3x630)	1890	NA	NA	NA	Above ground	NA	Fluor Corp.	1982 -- planned

Source: Abstracted from Hale, Dean, Cold Winter Spurs LNG Activity, Pipeline and Gas Journal, June 1977: 24 ,(Abstracted and reprinted with permission).

of exporting nations for an FOB (free on board) price comparable to the energy equivalent price received for oil exports. While this situation may change in the future as natural gas supplies continue to diminish, at present imported LNG must be "rolled-in" (averaged) with pipeline gas so that the average price for delivered gas is competitive.

Current Federal policy appears to allow such averaging of costs instead of requiring LNG be sold incrementally at its own cost. The Federal Power Commission in Opinion 796-A, issued June 30, 1977, reversed its own earlier ruling that LNG imports by the Trunkline Gas Company be priced separately to the user when FPC determined that such a requirement would render the Trunkline project unfinanceable, effectively preventing it from being attempted. The FPC concluded that the need for the additional natural gas promised by the project outweighed its inability to stand on its own economically under current conditions, and that it should not be delayed until future conditions made it economic. The FPC opinion suggested that other alternate sources for gaseous fuel -- deregulated natural gas, coal gasification, production of methane from geopressured zones, imports of liquefied petroleum gas (LPG), or manufactured (SNG) from petroleum liquids -- are not certain to be less expensive than LNG over the middle and long term. Therefore the FPC argued that LNG import projects, for which the technology is already available, should not be discouraged, because of the probable need for supplemental gas from some source in the future.

Besides considering how much LNG will be imported into the United States, it is important to examine the distribution and potential impact of LNG on regional natural gas supplies. Table II, prepared by the Energy Systems Planning Division of TRW, presents a forecast of expected State and regional dependencies on LNG. This data was based on projects previously filed with the Federal Power Commission, and was calculated by dividing estimated import levels by projected and prorated values for total consumption of gas for each State. According to TRW, the Northeast will have the largest dependence on LNG. New Jersey is expected to have the largest dependency of 47 percent of total gas use, followed by Vermont at 42.5 percent, and Connecticut and Arizona at 30.9 percent. 7/ Even though these exact percentages may change, the contribution of LNG to the gas supplies of the eastern United States and States like Ohio, Mississippi, Louisiana, Arizona, and California, may be significant if planned LNG terminals are completed.

Dependence on natural gas as a fuel has been established in virtually every part of the United States, and supplies of natural gas have been allocated during the growing shortage to those uses considered to be the highest priority. LNG imports may be imported in New England and other parts of the country far from the Texas-Louisiana center of natural gas production, because in these regions the high pipeline transportation cost component for natural gas makes LNG seem relatively economic. But if imported LNG is used in these regions, it will primarily supply residential

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7/ Fink, F.J. et al., op. cit., p. 51

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TABLE II: State and GRC Regional LNG Dependencies: Projected LNG Percentage of 1985 Projected Consumption for Projects Filed with the FPC. */

Region	LNG % of Area's Total Gas Consumption
NEW ENGLAND	28.1
Connecticut	30.9
New Hanpshire	28.9
Vermont	42.5
APPALACHIAN	12.1
Kentucky	3.6
Maryland	12.2
New Jersey	47.0
New York	9.5
Ohio	11.7
Pennsylvania	5.5
Virginia	8.9
West Virginia	4.5
SOUTHEAST	14.6
Alabama	20.8
Florida	6.2
Georgia	23.6
South Carolina	25.0
Tennessee	2.2
GREAT LAKES	4.5
Illinois	1.8
Indiana	19.0
Michigan	1.7
MID CONTINENT	.7
Missouri	2.9
GULF COAST	3.1
Louisiana	9.4
Mississippi	20.6
Texas	.7
PACIFIC SOUTHWEST	19.4
Arizona	30.9
California	20.9
Nevada	7.2

Source: R.J. Fink et al. of TRW, Inc. The Strategic Petroleum Reserve and Liquefied Natural Gas Supplies. 1977. p. 52.

and other high priority customers, building a perhaps dangerous reliance among critical needs, and lessening the utilization of the pipelines which brings natural gas from the Gulf region. If, on the other hand, LNG is brought primarily into the traditional natural gas producing areas along the Gulf Coast, it may be more difficult for it to compete with the other fuels among the lower priority users who would be seeking energy. Should natural gas supplies continue to decline to the point that imported LNG would be needed for continuous supplies to high-priority customers in regions distant from the producing area, its delivered cost would be increased by the pipeline costs. But at least dependency on imported supplies of natural gas could be equalized in differing regions.

The institutional changes that might be required by LNG policies should be noted. If those companies which build LNG terminals and receive shipments use the imported LNG exclusively, their service areas might become less vulnerable to domestic natural gas shortages, but more dependent on overseas energy sources and more vulnerable to a cutoff. However, any attempt to spread the risk or benefits of imports of LNG by allocating the gas among all or many pipelines or distributors would be contrary to the current structure of the natural gas industry, which makes each company primarily responsible for its supplies. If other companies may sometimes have to use LNG imports for peak needs, it may be appropriate to require them to make early contributions toward construction and operation of terminals.

Any sizeable increase of LNG imports would raise several questions including the following:

(1) Should the United States establish an LNG import policy?

(2) What physical or safety risks are involved in transporting LNG?

(3) Where and how should LNG facilities be sited?

(4) How efficient and effective is the Federal Government's regulation of LNG systems?

These issues and others are discussed in the following sections:

3.5.12.4 LNG Importation Policy

During the Ford Administration, the Energy Resource Council proposed guidelines to limit imports of LNG to 2 trillion cubic feet per year. Of that amount, no more than 1 trillion cubic feet could be imported from any one country. The Carter Administration has recommended in its National Energy Plan a more flexible policy that sets no upper limit on the quantity of LNG imports.[8/] Under the new policy, each application to import LNG would be reviewed with consideration for such factors as its availability at a reasonable price without undue risks of dependence on foreign supplies, the reliability of the selling country, the safety conditions associated with the importing terminal, and the total costs of the operation.

Several Federal policies and programs influence the contribution of LNG to the U.S. energy supply. For example, the quantity of LNG imported into the 48 States depends partly on Federal policy affecting LNG import levels and the capability of the Federal Government to supply loans, guarantees, or other forms of financial assistance if needed by LNG operators. In addition, the ability of the United States to compete with other countries for LNG supplies, the relative prices of energy fuels, and the willingness of foreign countries to enter the LNG market

8/ Executive Office of the President. The National Energy Plan. (Washington, D.C.: U.S. Government Printing Office, 1977), p. 57.

may have a considerable effect. The ability of gas companies to obtain the 140 or more Federal, State and local permits and regulatory approvals for a terminal also influences the rate of development of the domestic LNG industry.

There seems to be little coordination of the various Federal policies that affect the importation of LNG. Federal officials have indicated that the U.S. Government does not have a consistent policy on LNG imports. 9/ According to the Federal Energy Administration (FEA), the lack of such a policy has contributed to the planning problems of private industry, and has compounded the uncertainty which faces suppliers, consumers, and State regulatory groups as they attempt to deal with the natural gas situation. In addition, the lack of such a policy has enabled Algeria, a member of the Organization of Arab Petroleum Exporting Countries, "to emerge as the major prospective foreign supplier of LNG to the U.S., and as the potentially-dominant world supplier of LNG. " 10/

According to the FEA,

> The problem at hand is the definition of a comprehensive and consistent U.S. Government policy towards the importation of liquefied natural gas (LNG). This policy should be comprehensive enough to condition the operating practices of government agencies which have a major impact on the development of LNG import ventures; the principal relevant agencies at the Federal level are the Export-Import Bank, the Maritime Administration and the Federal Power Commission. 11/

9/ Office of Policy and Analysis (of the Federal Energy Administration). Outlook for U.S. Imports of Liquefied Natural Gas (LNG). Draft Report, Oct. 7, 1975, p. 1.

10/ Ibid., p. 1.

11/ Ibid., p. 1.

If the Congress chooses, as part of comprehensive legislation regarding LNG, it could influence or formulate an LNG importation policy. In developing such a policy, congressional review might consider the relative advantages and disadvantages of:

-- setting a limit on LNG import levels;

-- directing the distribution of LNG throughout the States now serviced by pipeline systems;

-- limiting the quantity of LNG that could be imported from any one country; and

-- relying on free market dynamics to determine LNG supply and demand.

In addition, congressional attention might be directed at ways in which Federal policy could be designed to help assure a "secure" supply of LNG at reasonable prices for the American consumer; Federal policy could foster the U.S. position in the international LNG market; and how Federal policy could reduce U.S. vulnerability to a potential LNG embargo.

3.5.12.5 Hazards and Safety Concerns

If decisions are made to increase the quantity of liquified natural gas imported into the lower 48 States, effective measures will be needed to ensure against the unique dangers it poses. These dangers include flameless explosions, enormous fires, radiant heat, flame inhalation, asphyxiation, frostbite, and uncontrolled vapor clouds. Unexpected release of LNG resulting from a collision of an LNG tanker, from faulty containerization of LNG on board, or from careless handling or improper storage or processing of the material on land could endanger life and property over a large geographical area.

The safety record of the LNG industry over the last 30 years has been good. Over 2,000 shipments of LNG have been made without incident. The more

than 60 LNG peak shaving plants now operating in the United States and Canada have had an excellent safety record. The industry's history, however, is not perfect. In 1944, a small LNG storage tank failed in Cleveland, Ohio, and a disastrous accident resulted in part because of lack of dikes and improper materials. Over 130 people died from the explosions and fires that resulted.

Debate over the risks of handling, transporting, and storing LNG is expected to continue, especially since expert opinion varies as to the most effective approach for prevention and remedy. Still to be faced is the major question of whether Federal, State, and local safety, construction, and siting regulations are adequate to allow the large scale importation of LNG to proceed, with acceptable risks to the public.

Although several congressional committees have examined the hazards and safety requirements of LNG systems, it appears that the increased use of this fuel may require new measures to further reduce possible loss of life and property.

Several options seem to be available to the Congress to accomplish this purpose, including:

(1) Further investigation of the adequacy of LNG safety regulations and their means of enforcement and, if necessary, enactment of legislation to re-design safety standards and to implement other appropriate measures.

(2) Review and expansion of Federal and industry research on LNG chemistry, transportation, and safety. Little is known about the phenomena that would result from a catastrophe involving LNG. Dr. Edward Teller recently stated that current understanding of the potential hazards from LNG accident is roughly comparable to our understanding of the hazards of

nuclear reactors 25 years ago. Research may provide more information on the properties and behavior of LNG, thus helping to assure that design, construction, and operation of vessels and facilities are reliable and adequate. In addition, research into the results of collisions by LNG tankers and the implementation of appropriate countermeasures may reduce the hazards of LNG accidents. As stated by Drake et al., it can be expected that further experience in handling liquefied natural gas and further research by the industry and by regulatory agencies will raise the level of safety in its use even higher.12/

(3) Review of the technical and financial capabilities of communities and private industry to contain LNG fires and, if necessary, enactment of legislation to enhance these resources. Hearings were held in the 94th Congress on H.R. 11459, a bill to establish a national marine firefighting program. This legislation, if passed, could have upgraded the capability of regional units to contain LNG fires.

(4) Investigate the technical feasibility and the legal considerations of constructing an offshore LNG facility designed to significantly reduce the risks to populated areas onshore.

3.5.12. 6 Siting of LNG Facilities Onshore

Deliberation among environmentalists, concerned citizens, and energy companies over the siting of LNG receiving and storage facilities have produced emotional controversy. Difficulty arises because sites located in either rural, industrial, or residential areas usually offer tradeoffs

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12/ Drake et al., op. cit., p. 29.

between environmental impact and safety. A site selected in a rural area raises concerns about the impact on the natural environment, even though a minimum number of people and amount of property might be endangered in the event of an accident. Industrial locations tend to have a minimum impact on the environment, but present a greater risk to human safety and industrial property. Siting of a storage or receiving plant near a heavily populated area could constitute a major safety hazard for millions of people and could result in enormous property damage in the event of a major LNG acciddent. Wherever these plants are sited, they must be designed and operated to prevent accidental and harmful releases of LNG.

Site selection is initially undertaken solely by the industry group proposing an LNG import facility. Federal and State Governments and other groups react to industry's proposal primarily through the Federal regulatory process. This regulatory system governing LNG import facilities is relatively complex, and generally requires several years of hearings and reviews before a company obtains all of the necessary Federal permits and approvals. Federal agencies that may exert a major influence on the siting of LNG facilities include: Department of Energy, Office of Pipeline Safety Operations, and the U.S. Coast Guard. Increasingly, State governments are demanding more of a role in the siting of LNG import facilities.

At present there is no Federal siting policy to govern the location and size of LNG plants throughout the United States. As a result, LNG facilities might be constructed in some coastal regions and not in others. It is also possible that LNG receiving terminals might be scattered along the coasts without long-range planning or proper management of the coastal zone.

Thus, there is reason to consider whether a Federal siting policy should be established; and if so, on what criteria should this policy be based. If a national siting policy were developed, it seems logical that its institution should precede the construction of a large number of LNG receiving terminals. Last year, Pennsylvania, New York, New Jersey, and Delaware petitioned the Federal Power Commission to promulgate national safety standards that would keep LNG port facilities out of populous areas. According to a New York Times articles of October 7, 1976, States officials suggested that the LNG terminals "be confined to areas of low population density, with suitable buffer zone maintained around them."

Recently, congressional attention has focused on these concerns. In the 95th Congress, Congresseman John Dingell and other members sponsored H.R. 6844, a bill to regulate the siting, design, construction, and operation of facilities to be used for the transportation, storage, and conversion of LNG. (President Carter's National Energy Plan suggested that strict siting criteria should foreclose the construction of new LNG terminals in densely populated areas. Congressman Edward Beard has introduced legislation (H.R. 9773) that would require the Federal Power Commission to withhold any license for LNG construction or expansion without the approval of the State or States involved. Senator Claiborne Pell has introduced legislation (S.2273) to confer on the Secretary of Energy jurisdiction over construction permits and operating licenses for liquefied natural gas facilities, and to provide the Governor or appropriate State officials with a major input into, and possible veto over, Federal siting decisions.

Local communities, State governments, and private industry may oppose a Federal policy which dictates the standards for siting of LNG terminals; instead, they may want to rely on the existing regulatory framework. Regardless of which option is selected, safety, environmental, and physical conditions are to be considered in any siting decision.

3.5.12.7. Siting of LNG Terminals Offshore

The concept of LNG terminals offshore is beginning to receive increased attention by Federal, State, and industry officials. The potential safety hazards to onshore areas from LNG operations may be lessened by moving part or all of the LNG receiving terminal and its associated storage tanks and regasification units many miles offshore. In the event of a spill or other mishaps, those miles of ocean might constitute an effective buffer, giving a combustible or explosive gas cloud more opportunity to disperse before reaching any populated areas. Environmental damage of a spill many miles from shore may be minor because of the quick evaporation of LNG.

In a study by the Stratos Division of Fairchild Industries, five different types of offshore LNG receiving terminals were considered as candidates for siting off the California Coast. These were: natural island facility, artificial island, floating facility, fixed and mobile structure, and subsea facility. Fairchild Industries concluded that each of these terminals was technically feasible. Even though Fairchild Industries judged specific sites to be environmentally acceptable, they concluded: "sufficient regulatory authority does not presently exist

to enable granting all of the approvals necessary for siting, constructing, and operating any offshore receiving terminal." 13/

Their report stated:

(1) No Federal legislation has been found enabling the granting of approvals for siting and associated leasing of an LNG terminal on the Outer Continental Shelf (OCS)

(2) No Federal legislation has been found enabling the granting of a gas transmission pipeline right-of-way and lease across the OCS for transport of gas other than that produced from submerged lands in the immediate vicinity of the pipeline. 14/

Henry Marcus and John Larson of MIT have arrived at similar conclusions. They maintain "there is no Federal agency with the power to authorize the siting, construction, and operation of an offshore LNG terminal outside the U.S. territorial seas. 15/ They also noted that the Department of the Interior does not have the authority to grant rights of way and associated leases for the laying of pipelines for an offshore LNG marine terminal in the OCS. 16/

The Congress may choose to address the regulatory and siting questions associated with the construction of an offshore LNG facility outside the U.S. territorial sea. According to Fairchild's report and the MIT study, it appears that congressional legislation is required before an offshore terminal is built on the OCS. Until this siting question is resolved, it is unlikely that industry would proceed with construction of an offshore LNG facilities on the OCS.

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13 Fairchild: Stratos Division. Offshore LNG Receiving Terminal Project. Volume I - Management Summary, March 31, 1977: 51.

14/ Ibid., p. 51.

15/ Marcus, Henry S. and John H. Larson. Draft Final Report: Offshore Liquefied Natural Gas Terminals. June 1977. pp.8-30.

16/ Ibid., p. 8-30.

decisions may also result in a weakening of the U.S. competitive position in the international LNG market. Potential suppliers of LNG may sell their product to countries whose policies facilitate the importation of LNG. For example, Indonesia may sell some of its supplies to Japan rather than to the United States, because U.S. regulatory delays have reportedly resulted in unconsummated contracts.[19/]

Congressional attention has focused on jurisdictional gaps, overlaps, and disputes between Federal agencies. For example, hearings were held in 1973 before the Special Subcommittee on Investigations of the House Commerce Committee to review Federal justisdictional responsibilities with respect to LNG storage facilities. The Subcommittee's report found that overlapping regulations of LNG storage safety had led to duplication of effort, fragmentation of responsibility, and inefficient administration.[20/] Some operators of LNG facilities maintain that they can adjust to one set of regulations, but two or more sets present major difficulties.

A regulatory system that allows reasonable plans to proceed with some degree of certainty is very important to the LNG industry.[21/] Several options are available to reduce or eliminate interagency conflicts and jurisdictional problems. Mandated cooperative efforts between agencies

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19/ Personal communication with David Ray of the American Gas Association, 1977.

20/ U.S. Congress. House, Committee on Interstate and Foreign Commerce. Special Subcommittee on Investigations. Legislative Issues Relating to the Safety of Liquefied Natural Gas Storage, 93rd Congress, 2nd Session, (Washington, D.C.: U.S. Gov. Print. Office, March 1974).

21/ Based on conversations with several industry spokesmen.

3.5.12.8. Federal Responsibilities and Regulations

Many Federal agencies regulate and influence the safety, siting, and economics of LNG receiving, storage, regasification, and shipping operations. The Department of Energy, U.S. Coast Guard, Army Corps of Engineers, Maritime Administration, Office of Pipeline Safety, Department of the Interior, and the Environmental Protection Agency have responsibilities over various aspects of LNG importing systems. State and local governments also affect LNG facilities.

The regulatory system governing LNG imports and facilities, is, by necessity, rather elaborate. Decision making related to the safety of planned facilities, siting of LNG terminals, and the priority of imported gas is detailed and requires extensive proceedings.

According to many industry spokesmen, the existing regulatory system for LNG systems is extremely complex and cumbersome. 17/ Numerous Federal, State and local permits and regulatory approvals are required for an LNG receiving terminal and its associated facilities. Delays in obtaining approvals from Federal, State, and local agencies have slowed many projects and have caused cancellation of others. 18/ In addition, delays in obtaining regulatory permits are a contributing factor to escalated costs for LNG facilities. Some of these increased costs are eventually passed on to the consumer. Delays in obtaining regulatory

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17/ Based on personal discussions with various industry spokesmen, 1977.

18/ Marcus, Henry S. and John H. Larson, op. cit., pp. 1-6.

(1) Federal policy on the importation of LNG, including questions of dependency, pricing, and distribution;

(2) Siting of LNG import terminals; and

(3) Safety and regulatory responsibility of various Federal agencies.

Since these issues are closely interrelated, they may need to be considered together, and within the context of other energy and environmental policies.

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is one option. Alternatively, the Congress could follow the suggestion of John Nassikas (former chairman of the Federal Power Commission) to enact legislation that would delegate or clarify responsibilities of the respective Federal agencies involved. Another course of action would be to designate one Federal organization, such as the Department of Energy or the Department of Transportation, as having primary responsibility for regulating LNG systems. Regardless of which option is chosen, it appears beneficial to resolve jurisdictional problems prior to shipment of substantially increased quantities of LNG into the lower 48 States.

In addition to its regulatory responsibilities, the Federal Government helps finance major LNG tanker construction projects. About 18 LNG carriers are being built, of which 11 are under Federal construction subsidy contracts. One of the largest Federal loan guarantees ever offered was recently awarded to underwrite construction of 7 LNG ships to be built by General Dynamics in Quincy, Mass. The first of these ships, LNG-41, is now completed.

3.5.12.9. Summary

In view of the projected U.S. gas supply situation, increased quantities of LNG are likely to be imported into the lower 48 States. Because of questions of energy policy and the inherent dangers of transporting, storing, and regasifying this fuel, Congress may choose to become increasingly involved in the formulation of policies affecting the importation and regulation of LNG.

This chapter has identified three areas of concern that appear to warrant additional attention:

Prudhoe gas reserves are center of pipeline battle. Oil and gas journal, v.72, November 25, 1974: 96, 100, 102, 104, 106, 108, 112, 114.

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APPENDIX III

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LIQUEFIED NATURAL GAS:
MAJOR LEGISLATION AND ISSUES BEFORE THE 95TH CONGRESS

[Prepared for a CRS seminar on February 1, 1978]

Paul F. Rothberg
Analyst in Physical Sciences
Science Policy Research Division

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LIQUEFIED NATURAL GAS: MAJOR LEGISLATION AND ISSUES BEFORE THE 95TH CONGRESS

I. Introduction

This report presents a list of current legislation and issues pertaining to the importation of liquefied natural gas (LNG).

In the first section, current legislation regarding LNG safety, siting, and import levels is summarized. 1/

The second section presents a selected list of major issues associated with the emerging LNG import industry. These issues have been discussed in congressional and executive hearings, in studies on LNG by the Congressional Research Service (CRS), Office of Technology Assessment (OTA), and General Accounting Office (GAO); and in the technical and policy literature. A bibliography on LNG safety, siting, and policy issues is presented in Appendix I.

In the last section, provisions of current legislation are compared to a list of major issues concerning LNG.

1/ In the interest of brevity and by necessity, many details and provisions of these bills are not cited. The reader should refer to the original bills for a complete accounting of their intent.

II. Major Legislation Introduced in the First Session of the 95th Congress

Legislation pertaining to LNG safety, siting, and import levels includes:

A. S. 2273;

B. H.R. 6844;

C. H.R. 9731; and

D. H.R. 9773.

A. S. 2273, "Liquefied Natural Gas Siting and Safety Act". Introduced by Mr. Pell, November 1, 1977. This bill gives the Secretary of Energy jurisdiction over construction permits and operating licenses for LNG facilities, and directs the Secretary of Energy (hereafter referred to as "Secretary") to promulgate such regulations as may be necessary to establish minimum standards for the location, design, operation, and construction of LNG facilities. S. 2273 provides that after June 30, 1977, a LNG facility cannot be constructed without a permit issued by the Secretary.

Under the terms of S. 2273, in order for the Secretary to issue any LNG construction permit, the Governor or a responsible agency of the affected State, must approve the specific location of the proposed facility. However, the bill allows the Secretary to issue a construction permit without this approval, if the Secretary determines that the LNG facility at the locations specified is necessary for national security reasons. S. 2273 mandates that a hearing be held in the affected local district on an application to build a LNG facility.

S. 2273 directs the Secretary to report to Congress his recommendations concerning creation of a compensation and liability fund to protect

the public against risks associated with construction and operation of LNG facilities.

The Secretary, in consultation with other Federal agencies, must report to Congress on the adequacy of current Federal research and development efforts relating to health, safety, and environmental control in connection with LNG facilities. S. 2273 charges the Secretary with primary responsibility for Federal research and development relating to health, safety, and environmental control in connection with LNG facilities. This bill also names the Secretary as coordinator of Federal research and development activities in this area.

B. H.R. 6844, "Liquefied Natural Gas Facility Safety Act". Introduced by Mr. Dingell and Mr. Markey, May 3, 1977. This bill affects the siting, design, construction, and operation of facilities used in the transportation, storage, and conversion of LNG. H.R. 6844 directs the Secretary of Transportation (hereafter referred to as "Secretary") to prescribe minimum standards for determining the location of any new LNG facility and standards for their design, construction, and operation. The Secretary is directed to prescribe standards for the location and operation of existing LNG facilities.

H.R. 6844 mandates that no new LNG facility may be constructed unless a permit has been issued by the Secretary. The bill also specifies that except for certain exemptions, no new or existing LNG facility may be operated unless a permit has been issued by the Secretary. A permit may not be issued unless an adequate contingency plan setting forth steps to be taken in the event of a LNG accident is provided to the Secretary. In addition, assurances must be given that there is adequate financial coverage

to satisfy claims for personal injury and property damage resulting from the most severe LNG accident which could be expected.

H.R. 6844 prohibits the Secretary from issuing a permit "in the case of the construction of (or with respect to) any liquefied natural gas facility which is stationary and --

(a) any portion of such facility located within 2,000 feet of any residential structure, or

(b) the population density of the area within eight miles of such facility averages 10 or more persons per square mile (taking into account those who either work or reside within the area),

the Governor of the State in which such facility is to be located notifies the Secretary in writing that he does not object to such construction." The bill also provides civil penalties for certain violations pertaining to the construction or operation of LNG facilities.

H.R. 6844 states that a political subdivision shall not have its laws or regulations pertaining to LNG facility standards preempted (under this bill) unless these standards are incompatible with the standards set forth in this bill. The Secretary of Transportation is also directed to coordinate his actions under this proposed Act with those taken by other Federal agencies.

H.R. 6844 also directs the President to determine tentatively the maximum amount of imported LNG to be authorized during each of the following 10 years, and to determine the number, size, and type of additional LNG facilities needed to accommodate this fuel. The bill authorizes $4 million for the Secretary to conduct a LNG safety study.

C. H.R. 9731, Amends the Natural Gas Act. Introduced by Mr. St. Germain, October 25, 1977. H.R. 9731 amends the Natural Gas Act so that a certificate

for the construction or extension of any LNG may not be issued "unless the Governor of the State and the legislative body or bodies of that State in which such facility is to be located has approved in writing such facility."

D. H.R. 9773, Amends the Natural Gas Act. Introduced by Mr. Beard, October 27, 1977. This bill amends the Natural Gas Act to provide that no certificate for the construction or extension of any LNG facility may be granted unless approved by the affected States. H.R. 9773 specifies that "no standard or requirement imposed by the State as a condition of its approval (other than a requirement solely relating to facility location) may be inconsistent with any standard or requirement applicable to such facility . . ." pursuant to the Natural Gas Act.

III. Selected Major Issues Concerning the Importation of LNG

Primarily since 1970, numerous congressional and executive hearings, regulatory proceedings, and technical meetings have been held concerning the importation of LNG. During these activities, major issues associated with the importation of LNG have been identified. The CRS, OTA, and GAO have also completed several reports which discuss issues concerning the importation of LNG.

In this section, seven major issues concerning the importation of LNG are listed. A series of questions are posed to elaborate some of the unresolved questions associated with each issue. The interested reader who wishes to gain an understanding of these issues is referred to the bibliography presented in Appendix I.

A. Issue #1. Safety of LNG Import Systems. What are the risks and dangers involved in importing, storing, and regasifying large quantities of LNG? Are Federal, State, and local safety, construction, and operating regulations adequate to allow increased LNG importation to proceed with acceptable risks to the public? Should training requirements for LNG crews and personnel inspecting and regulating LNG tankers and facilities be upgraded? Do local fire departments near a LNG facility have the expertise and financial resources to prepare themselves for dealing with a possible LNG emergency?

B. Issue #2. Research and Development Pertaining to LNG Operations. Are Federal research efforts on LNG safety and operations adequate? Should the Department of Energy intensify its efforts in this area? How timely will additional information be? Can Federal research efforts be better coordinated? Which agency head should have the major or lead responsibility

in this area? Are Federal research efforts focused on the major areas of concern?

C. Issue #3. Liability for LNG Accidents. Should liability limits be established for LNG terminal and vessel operators? Should the Congress establish a LNG damages fund to help pay compensation in the event of a LNG disaster? Should Congress adopt legislation to ensure adequate liability insurance which defines coverage and responsibility for LNG accidents?

D. Issue #4. Siting of Onshore LNG Facilities and States Rights. Should new LNG import facilities be located only in "remote" sites? Should the Federal Government, local communities, or State governments establish LNG facility siting criteria? What criteria should be considered? Should one government institution be allowed to preempt the authority of another over the siting of a LNG facility? Should a Governor or State legislative bodies affected by a LNG proposal be given the authority to veto a Federal siting decision? What role should the public have in establishing LNG siting criteria? Is a national LNG siting policy needed? What role, if any, should the Coastal Zone Management Act of 1972, and its subsequent amendments, play in the siting of LNG facilities? Should existing LNG storage tanks located in heavily populated areas or those that do not meet strict siting criteria be phased out?

E. Issue #5. Siting of Offshore LNG Facilities. Does the legislative authority exist for LNG facilities to be located offshore?

F. Issue #6. Pricing and Importation of LNG. Should incremental or rolled in pricing be allowed for LNG? 2/ What role should LNG play in the

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2/ Incremental pricing means that each customer using LNG is charged the full cost of the amount of LNG he actually uses. With rolled in pricing, the customer pays a price determined by the weighted average of all gas used by a company.

U.S. energy situation? How secure are LNG supplies? How dependent should the United States become on imported gas supplies, including LNG? What role should Congress play in determining the level and pricing of LNG imports? Should a limit on LNG import levels be set?

G. Issue #7. Federal Regulation of LNG Facilities and Operations. How can the Federal regulatory system which affects approval, siting, and operation of LNG facilities be improved? Can and should the regulatory process be accelerated? Do conflicts exist between the regulations and rulings issued by the Coast Guard, Office of Pipeline Safety Operations, Federal Energy Regulatory Commission, and the Economic Regulatory Administration? Does Congress need to provide guidelines for the division of responsibility of Federal agencies that promulgate and enforce LNG safety and siting standards? Can the Federal regulatory system be redesigned to better meet the needs of consumers and requirements of industry? Should Congress increase the staff of the Office of Pipeline Safety Operations so LNG facilities will be more rigorously inspected?

IV. Matrix Comparing Legislation to Major Issues

Presented below is a matrix which compares major provisions of the legislation before the 95th Congress to the list of issues concerning the importation of LNG. Bills are listed on the top portion of the matrix; issues are listed on the left side of the matrix. Whenever, a provision of a bill is relevant to an issue, an "X" is indicated.

LEGISLATION INTRODUCED IN THE FIRST SESSION OF 95TH CONGRESS

MAJOR ISSUES	H.R. 9731	H.R. 9773	H.R. 6844	S. 2273
Pricing of LNG				
LNG Import Levels			X	X
Federal Regulation of LNG Import Systems			X	X
Safety of LNG Systems			X	X
Offshore Siting of LNG Systems				
Onshore Siting of LNG Facilities	X	X	X	X
Federal Versus State Authority Pertaining to the Siting of LNG Facilities	X	X	X	X
Research and Development on LNG Systems			X	X
Compensation and Liability Concerns Related to LNG Accidents			X	X

V. Conclusions

The bills concerning LNG that were introduced during the first session of the 95th Congress seem to be intended primarily for preliminary discussion. In their current form, these bills would continue the Congress' limited role in determining major policy issues associated with commercialization of the LNG importing industry. For example, none of the bills would give the Congress a major input into deciding whether LNG should be incrementally priced or rolled in. These bills do not provide the Congress with a major input into deciding the level of LNG imports and the relationship between LNG supplies and U.S. energy policy. (Although these decisions affect millions of U.S. gas consumers, the Congress has had only a minimum role in deciding these issues.) In addition, none of the bills have addressed all of the major concerns associated with the emerging LNG industry.

The timing of future congressional decisions on LNG is important. Within the next two or three years, executive agencies are likely to approve the plans of several major LNG import facilities.

APPENDIX I

BIBLIOGRAPHY ON LIQUEFIED NATURAL GAS

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